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HEREDITY.*

By Prof. W. E. Castle, Harvard University.

The conservation movement now in progress has for its end to preserve for future generations of men the natural resources of the earth. But it goes without saying that the movement is useless unless there are to be future generations of men capable of utilizing those resources. Thoughtful persons are beginning to wonder whether this is assured. Man is the product of two sets of agencies which we summarize in the terms heredity and environment. The question has often been asked which of these is the more important, but with this we need not concern ourselves. Both are indispensable. Seed and soil combined assure a harvest, but if either is lacking no harvest can be expected.

The public is awakening to the importance of providing mankind with a proper environment through the agencies of sanitation, education and good government, and this is well. This assures a suitable soil in which a crop of healthy human beings may develop. But what of the seed? This question has not yet been seriously considered. Only in England has it been more than suggested. There Francis Galton and his associates in the eugenics movement have started an inquiry as to why it is that the average physical condition of the English nation is declining although more and more attention is constantly being given to improving the environment. Likewise in Germany statistics show a steadily declining proportion of the young men fit for military service. There is a suspicion in the minds of many that these nations are producing the new generation of citizens chiefly from inferior family and racial stocks. If this is so the remedy is obvious, though how easy of application remains to be ascertained. Would a farmer expect to have full harvests if each year he saved seed from the poorest yielding plants, or could he hope to secure the best results from his herds by selling or butchering the best stock and keeping only the scrubs? Obviously not, and no more can the civilized nations maintain their present standards of manhood if they follow a like practice.

But before any serious attempt can be made to improve the human race considered as an assemblage of animals possessed of certain desirable physical and intellectual attributes, it is obvious that we must know something about heredity in general, and how in particular each of the desired physical and intellectual attributes is produced. Considerations such as these lend general interest to the study of heredity, a subject which has always been of great practical concern to farmers, and of much theoretical interest to scientists. It is my purpose to review briefly some of the problems which the study of heredity presents, and some of the results obtained from their consideration.

"Like father like son" is a homely proverb which shows how general the recognition is that children resemble their parents. Resemblances to grandparents or ancestors even more remote are also of frequent occurrence, and it is convenient to use the term heredity as including all such resemblances, whether to near or to remote ancestors. The phenomenon of heredity is of course not restricted to human society.

(Continued on page 376.)

* Lecture delivered before Section F, American Association for the Advancement of Science, here reprinted from the Popular Science Monthly.

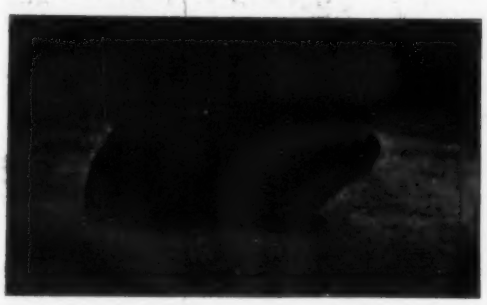


FIG. 1.—A YOUNG BLACK GUINEA-PIG.
About three weeks old. The ovaries taken from an animal like this were transplanted into the albino shown in Fig. 2.

FIG. 5.—A BLACK FEMALE GUINEA-PIG AND HER YOUNG.

FIG. 2.—AN ALBINO FEMALE GUINEA-PIG.
Its ovaries were removed and in their place were introduced ovaries from a young black guinea-pig. Compare Fig. 1.

FIG. 4.—A GROUP OF THREE YOUNG.
Produced by the pair of albinos shown in Figs. 2 and 3.

FIG. 6.—AN ALBINO GUINEA-PIG.
Father of black young like those seen in Fig. 5.

FIG. 7.—TWO OF THE GROWN-UP YOUNG OF A BLACK AND OF AN ALBINO GUINEA-PIG.

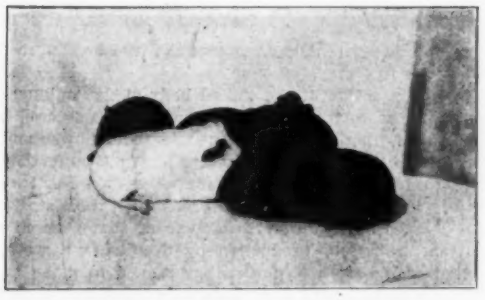


FIG. 8.—A GROUP OF FOUR YOUNG.
Produced by the animals shown in Fig. 7.

FIG. 3.—AN ALBINO MALE GUINEA-PIG.
With which was mated the albino shown in Fig. 2.

IRISH LINEN.—II.

SOME FEATURES OF ITS PRODUCTION.

BY SIR WILLIAM CRAWFORD.

Concluded from Supplement No. 1796, page 363.

VERY considerable improvements have taken place in the spinning mills and weaving factories with regard to the conditions under which the operatives work. Chief among these is the diminution which has been effected in the amount of dust floating in the air of many of the rooms. In this improvement Mr. R. H. Reade, chairman of the York Street Flax Spinning Company, Limited, has been the pioneer. The first distinct step in clearing the dust out of the dusty rooms was to localize the exhaust, that is to say, to collect the dust as near as possible to the point at which it is produced, and the principle has been gradually applied, beginning with the worst places in the mill. The final result might almost be described as a revolution, so marked is the improvement in the atmosphere compared with what was looked upon as the normal and inevitable dusty condition of these rooms twenty years ago. In the wet spinning rooms, close attention to the design and condition of the trough lids, coupled with better covering of steam pipes and general exhaust ventilation, has greatly reduced the excessive heat and moisture of the rooms, and brought the last well within the limits imposed by the Home Office. In weaving sheds, the better distribution and more extensive application of ventilating and exhaust appliances to satisfy the standard of air purity required by the Home Office, has likewise improved the conditions there, though to a less marked degree than in the spinning. These changes have been introduced by the masters partly on their own initiative, and partly at the instigation of the Home Office inspectors, and have brought about a distinct and much-appreciated improvement in the health of the workers. Their trade unions have formally acknowledged the benefits they have derived.

Perhaps the improvements in the machines used in the flax industry have not been so rapid or so great as in some other textile industries. However, there have been some, and I may tell you of one that is now coming into extensive use in the hackling of flax. This invention, due to Mr. James G. Crawford, can be attached to the ordinary hackling machine. Formerly four boys were needed to attend to a pair of hackling machines, and the work devolving on each of the four boys was extremely arduous—so arduous that they remained at it only so long as they were unable to obtain work in another industry. By this invention one boy can attend to a pair of hackling machines instead of four boys, and the one boy's work is extremely light. It thus effects a saving of 75 per cent in wages, and in addition the work is better done, and practically all the boys can be retained and advanced to apprenticeship in one or other of the trades connected with the flax industry.

A recent action of the united body of flax spinners is, I think, worthy of being recorded to their credit. In 1908, during a period of unexampled dullness and depression, those masters, finding that, although they had for some months been running their mills two-thirds time in order to lessen production, their stocks continued to rise, resolved in June of that year still further to reduce production by five hours a week. At the same time, however, they agreed to make no further reduction in the wages of women and young people employed by them. And this payment of unearned wages for five hours a week continued for seven months, and constituted a gift of about $150,000. I have never heard of a similar act elsewhere. In 1906-7 spinners' wages had been advanced by 20 per cent. Therefore a woman who before 1906 had been earning $2.45 a week of 55 hours was temporarily, in the time of stress, paid $1.96 per week of 32 hours.

We now come to the third division, viz., bleaching. In olden days that process could be carried through only in the long days between March and October, and it was produced by primitive methods, such as boiling the linen in lye made from burned seaweed, and then spreading it on the grass field exposed to the effects of sun, air, and rain, and artificial watering. After six months or so of this treatment, the linen was steeped in buttermilk, washed in pure water, and finished up. The color obtained by these methods was not so white as is now common, but the bleached linen retained a high proportion of its natural strength. With steam-driven spinning machinery there ensued so great a development of linen manufacture, and of the demand for it from foreign markets, that a quickening of the process of bleaching became necessary. A white color was also demanded, and so the use of more chemicals, with shorter exposures on the grass, became the rule. The manner of bleaching that has been carried on for many years past is something like the following: 140 webs of yard-wide brown linen, each one marked on the end with red thread in a way to be identified, are stitched together end to end into one piece of say 10,000 yards. This is called a "pot," and in common parlance is spoken of as "she." It is first passed through a solution of lime into the boiling pot, and there boiled eight or ten hours. It is then drawn through a tank of water. The webs are unsewn, each one is bundled separately, they are washed in the wash mills with pure water for an hour, then steeped in a sour of dilute hydrochloric acid, to convert the residue of the lime into a soluble salt; washed again in the mills, boiled in soda lye, which, combining with the waxes and fats in the fiber, make them into soap, and hence removable; washed again, put on the grass for some days, boiled again in lye, washed, put on the grass, rubbed in soap and water, boiled in lye, washed, put on the grass, and so on.

As soon as it is considered to be sufficiently boiled the whitening process is begun by the use of bleaching powder or "Dip" in which the cloth is left over night. It is washed, treated with weak sulphuric acid, boiled again with soda lye, such processes being repeated until the cloth is found to be of a proper whiteness. The webs are once more stitched together and the process of finishing begins: The cloth is breadthed, passed through a water mangle between rollers which leave just the proper moistures for taking starch, then into and through a tank filled with a mixture of blue and starch, after which it is passed over heated rollers to dry it. The webs are once more unsewn, they are put on the beetling beams and beetled for four or five hours, turned on the beams, and beetled for another four or five hours, and so on till they have had thirty to sixty hours of beetling. They are then aired, stretched to the full width, and calendered.

This completes the work of the bleacher, the whole occupying eight or twelve weeks. If an inquiry is made of a bleacher how is a certain pot coming on, or at what stage is it? the reply will probably be, "She" is doing well, or "She" is ready for the blueing. A witty, or shall I call him a wicked bachelor, once suggested that a pot was called "she" because of its being so hard to bring it to the right point! Linen bleaching is not only a very risky business, but it has also been an unprofitable one, so the Irish bleachers and the Scotch bleachers have recently been obliged to form an association binding them to regulate their prices and terms by common agreement. They are entitled to have a fair living out of their business, and may have it without injuring the other sections of the trade.

In linen bleaching there is a field for the services of chemical research. The present methods carry with them serious risks of damage to the goods. A pot may be taken as worth $2,500, and in the North of Ireland seven or eight thousand of such pots are treated each year. One may thus form an idea of the magnitude of the risk. Here, then, is a practical object for our scientific men to have before them.

The preparation of linen goods for the market is a somewhat elaborate process. When the webs are received from the bleaching works they are carefully examined and any defective portions laid aside. They are then lapped or folded, and, it may be, ornamented to suit the taste in each market. Elaborate folding and costly ornamentation, once so common, are now, however, fast disappearing. Great changes have taken place in the methods of selling the products of flax, the tendency being to eliminate the middleman. Formerly spinning was the sole business of a firm, whose yarns, through one or more intermediaries, reached the weaver; weaving, the sole business of another firm, whose goods were sold to the merchants through another intermediary. Bleaching was the business of a third; the goods were then sold to a merchant-shipper, who sold to wholesale houses either at home or abroad, and these sold to the shops. But now two or more of these operations are the business of one firm, while some of the largest houses carry through all the operations, and by means of travelers, speaking the language of the countries where they go, sell direct to the wholesale houses abroad, and even in some instances to the shops. Some firms also have, in the principal using centers, branch houses where stock is held, and is sold to the shops as they may require it in the currency of the country.

The Companies' Act of 1862 and later ones have been availed of largely by the firms engaged in the linen industry. The York Street Flax Spinning Company was the first in Belfast to be registered as limited. That was done in 1864. Almost every firm of any importance in the linen industry of Ireland is now limited. Some of them print their accounts and send them freely to their shareholders, and their shares may be bought by the public. Other firms are "private limited," do not publish their accounts, or allow their shares to be offered to the public.

It is an advantage, as tending to stability of its business, for a firm to be limited, in that money put into shares cannot be withdrawn from the company, whereas if a partner of a private firm dies his capital may have to be paid out, and that may cripple the firm. Limited liability also tends to facilitate the extension of a company's plant and operation as it is supposed to have a perpetual life, and the shareholders cannot be involved beyond the sum to which they are committed by the shares they hold, and further the general public have, by means of it, access to participation in the profits of the industry.

In the linen industry there has been no amalgamation of firms, except perhaps the Linen Thread Company. But there have been working agreements among masters for the settlement of wages, for reducing output, and in one instance, to maintain a minimum price for yarns. This latter agreement among flax spinners, come to in 1908, to hold yarns in stock rather than sell them below the price that had been fixed, was irksome to some of the spinners, but it is now acknowledged by all of them to have been good for themselves and for all connected with the trade.

I must not omit to mention the large and prosperous linen thread industry, in which the leading firm is Messrs. William Barbour & Sons, Lisburn. If I do not enter on that interesting subject it is simply because I know too little about it. There are also many other branches of the linen industry which time will not allow me to speak of. A feature of the industry is the numerous ramifications into which it branches, and the comparatively small quantity of each article that has to be manufactured. This is indeed one of the safeguards of the position. It tends to prevent other countries, such as the United States, from making such goods themselves.

The relations between masters and employees in the linen industry are of a more friendly character than in most other industries. In many instances one generation is succeeded by its descendants, and sometimes to the third or fourth generation, in the service of the same company. Conferences in an amicable spirit have sometimes taken place and arrangements of wages been agreed upon without recourse to strikes, which have been rare and always of small dimensions.

A rough estimate of the capital employed in the Irish linen trade might be made up as follows: 935,000 spindles at an average price of $25 each, $23,375,000; 36,000 power looms at $250, $9,000,000; bleaching, printing, and finishing works, estimated at $2,500,000. These amounts added together would show a total of $34,875,000 in plant alone; in addition to which the stocks of raw material and of goods in process of manufacture and in a finished state would be value for $25,000,000 or $30,000,000. Then there is a further amount of capital employed in giving credit to buyers, and, whether this be in the form of discountable bills or of open accounts, capital to the extent of over $10,000,000 is required to do it. The grand total of capital employed would thus amount to at least $70,000,000.

One might estimate the amount paid in wages to the operatives as follows: 70,382 men, women, and young persons, at an average of $3.12 per week, $11,435,000; bleachers, printers, and finishers, $2,020,000; embroiderers, hemstitchers, and warehouse hands, including lappers, ornamenters, and box-makers, $2,000,000; hand-loom weavers, $275,000. Besides all these there are clerks, managers, and other officials whose salaries would amount to $1,250,000; and if 5 per cent on capital, $3,500,000, be included it would show a grand total of $20,360,000 distributed annually; and three-quarters or more of it is drawn from foreign countries, as much

* Journal of the Royal Society of Arts.

the greater portion of Irish linen products is sold outside of the United Kingdom.

Linen manufacturers ought, of course, to manufacture nothing but linen goods. Unfortunately the stress of circumstances forces them to extend their manufactures to unions, that is, goods into which enter both linen and cotton yarn. In order to meet and satisfy, as far as possible, a craving on the part of buyers for low-priced goods, having some appearance of linen, this has long been found necessary. The making of unions is justified in the case of fancy dress goods, as undoubtedly cotton takes and holds dye stuffs better than linen, the fiber of it being softer and more penetrable. Very beautiful and becoming dress goods are being woven in such unions. But into that part of the trade I shall not enter. What has been set as my text is *linen*—linen the most ancient of textile fabrics. It is hoary with age, and with the most sacred associations and charming memories, and that it should have to struggle for life now in the fiftieth or perhaps the one hundredth century of its useful existence is at least pathetic. Cotton is known to have been in use as a textile for 2,000 years or so. The name calico was given because it was first shipped to us from Calicut in India. It was in America before Columbus. But, as compared with linen, the cotton industry, its great and formidable rival, is a juvenile. It is only within the last 100 or 150 years, by the invention of the spinning jenny, the power loom, and the fly shuttle, that cotton has come really into common use, and that its industry has assumed the gigantic proportions of to-day. The linen merchant now meets it as an opponent at every turn, and he is so hedged in by it that the linen industry has been barely able to avoid a serious contraction.

Among the reasons why cotton is so formidable a competitor of linen, the following may be mentioned. Although the cost of flax and of raw cotton do not differ very much, cotton has a great advantage over flax in the ease and cheapness with which it is manufactured. In the first place, the hard and inelastic nature of the flax fiber makes a much more expensive type of machinery necessary for its spinning. A cotton mill can be erected complete for about $6.62 a spindle, whereas a flax-spinning mill would cost from $30 to $40 a spindle. Then the great variations produced in any one field of flax necessitate elaborate and costly hackling and sorting, in which about 50 per cent of it becomes tow of comparatively low value, raising the cost of dressed flax fully 50 per cent above that of raw flax. Cotton, on the other hand, is very uniform in quality, and is cheaply carded with little loss of material or of weight. Its elasticity allows of the employment of machinery so largely automatic that the number of workers in a cotton mill would be about one quarter of those in a flax mill of the same number of spindles, while at the some time the turn-off of a cotton spindle is considerably greater than that of a flax spindle. The advantage in favor of cotton does not end with its conversion into yarn, for it is more easily woven than linen, and finally it is bleached more quickly, with less risk of damage, and with less loss of weight. Nothing but the inherent beauty and excellence of the flax fiber has permitted its survival of competition so formidable. The position of the linen trade is a trying one, but the experience of the past leads to the hope that the staple trade of Ulster will continue to survive during many future generations. To have held the supremacy in the fine linen trade against the world is, I trow, another flag saved by Ulstermen for the British Empire.

SHELLAC AND THE LAC INDUSTRY.*

A MYSTERIOUS AID TO CIVILIZATION.

BY G. CLARKE NUTTALL, B.SC.

SHELLAC or lac is one of those aids to civilization about which there has tended to be an atmosphere of mystery and romance.

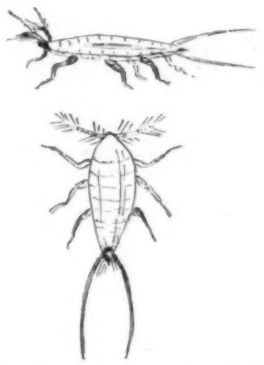
Already familiar to us in the form of sealing wax, varnish, furniture polish, hat-stiffening, and the like, and, of course, in the decoration of every conceivable thing hailing from India—trays, boxes, tables, beds, shields, and a hundred and one other things—it is, nevertheless, quickly rising now into vastly greater importance because it has been found essential in electrical work (whose immense development has been of such mushroom growth the past few years), and because, too, it is largely required in the preparation of gramophone records. Hence the exports from India have quadrupled, and in 1905 no less than 6,000 tons of it were imported into the United States alone.

Now the lac industry is of great antiquity. Thousands of years ago, in prehistoric times, the natives knew its value and used it largely. There are various references in Sanskrit literature to the lac tree, that is, to the palas or dhak. In 1590 the great Akbar wrote full particulars as to how lac resin should be used in varnishing the wood of public buildings. The first European who described it was a Dutchman who was sent on a scientific mission to India in the sixteenth century by the King of Portugal. He published his knowledge of its use and value in 1596—a translation was soon after made in England—but he had no idea whatever of the true origin of the wonderful resin. Since that time, it is true, we have learnt much about it, but with this sudden leap in value and importance there has now come a great accession to our knowledge.

Last year, in an admirable treatise, the Forestry Department of the government of India, through Mr. Stebbing, enabled us, perhaps for the first time, to obtain a perfectly definite and clear idea of its origin, nature, and manipulation, and of the life history of the insect to which it owes its existence. For shellac, or lac, as it is generally termed in the initial stages, is a product of the animal kingdom, and may be defined as a resinous excretion by a scale-insect known as *Tachardia lacca*, a close relative of bugs, plant lice, and the like, and a native of India. It lives upon many varying native trees, though the kusam (*Schleichera trijuga*), the dhak (*Butea frondosa*), the pipal (*Ficus religiosa*), and the arhardal (*Cajanus indicus*) are its favorites. It is also found, at times, upon the banyan (*Ficus bengalensis*) and upon the mango (*Mangifera indica*).

Great numbers of these insects dwell closely together upon the trees, and each proves to be nothing more or less than an animated miniature syphon. At the mouth of every one is a tiny lancet with which it pierces the tree, and through the opening thus made it inserts a sucking apparatus. Then it proceeds to draw up into itself the living sap of the tree; this passes through its body, is modified in the process, and passes out again at the other end in the form of lac. The lac accumulates and is gradually built up round the insect into a small, red, dome-shaped excrescence. Owing to the myriads of these excrescences they tend to run into one another and form a regular incrustation on the branches.

The life history of the insect may be summarized as follows, though it varies in detail in different parts of India: About the beginning of July tiny red larvæ can be seen swarming out of the incrustations in countless numbers and spreading over the neighboring twigs. Each is oblong in shape, with two minute eyes, two short antennæ or feelers, and six short legs. Curious tufts of white powdery hairs—the breathing apparatus—grow from each side of the thorax. This swarming goes on for two or three weeks, not all the insects appearing at the same time, but each, as it appears, immediately sets to work to find a suitable



SIDE AND DORSAL VIEWS OF THE LAC INSECT.

position where it can set up as a "syphon" on its own account. Within twelve hours its fate is sealed, and during this time it takes no nourishment of any kind, as its whole attention is taken up with settling itself in life. A certain number will be successful, but a far larger number are doomed, owing to their not being able to bore through the cortex at the point they attempt it, and hence cannot get at the sap.

A successful insect, however, settles to work, and for about two and a half months goes on steadily forming lac incrustation, the female producing a bigger structure than the male. At the end of this time the males creep out backward from under the edge of their scales; they have grown a little since we saw them first as larvæ, and have now larger antennæ and four eyes instead of two (two more having appeared under the head), and they crawl over the twigs looking for the females, and fertilizing them. Then they die, their life work quite finished. The females go on forming lac for another two and a half months, and developing too; then for a month, the last month of their lives, they rest dormant, taking no nourishment, lying inert. The eggs hatch out within them, perhaps a thousand in number in each, and the larvæ emerge and swarm, trying to find new homes while the mothers shrivel and die.

There are thus two generations in every year, the second generation beginning to swarm in the early part of December and distinguished by the single fact that the males have wings.

Now, the lac insects have various enemies to contend with during their short life. Birds are on the outlook for the larvæ when they first swarm, and monkeys like the sweet-tasting lac, and will eat it in considerable quantities and include the insects, too, in their meal. Ants are still greater pests to them, for though they do not deliberately eat up the insects themselves, yet they feed on the lac with avidity, and often injure the insects in so doing. Certain caterpillars, too, will prey upon the lac insect, and rain, frost, and hail are often injurious to large numbers.

Lac is almost invariably collected by natives, and the collection is made by breaking off the incrusted branches and twigs. These are sold as "sticklac" to middlemen who take them in large quantities to factories. Here they are broken up into short lengths and crushed either by hand or by machinery. This crushed matter is divided into three parts—(1) the wood, which is used up as fuel; (2) the dust—"khud"—sold to makers of bangles and toys; (3) the true granular lac which is known as seed lac. The next process is to wash the seed lac for twenty-four hours; the water which runs away from it is a deep purple color and formed the once valued lac-dye, but is valuable no longer, as it has been supplanted by aniline dyes. Drying follows, the substance being spread out and finally bleached. At this stage it is often mixed either with resin to lower its melting point, or with orpiment (yellow arsenic) to make it opaque, or with both substances at once. The mixture is then put into very long, narrow cloth bags, 10 to 12 feet long and 2 inches wide, and held over open fires. The worm-like bags are slowly twisted and the melting lac oozes and drops on to the floor. It is then stretched into thin sheets and sold as shellac. All fragments and parings are carefully secured throughout the whole manufacture; nothing is wasted, and these inferior qualities are sold as button-lac and garnet-lac.

Hitherto the cultivation and collection have been almost entirely in the hands of the natives, and hence the methods employed are of the original primitive character. But now shellac is becoming so valuable and the demand for it is increasing so fast that the government of India is beginning to interest itself more closely in lac cultivation, and the Forest Department has been intrusted with the work of forming lac preserves. The matter has become more urgent during the past four years since the price began to rise, and prompt action is felt to be advisable. In 1896 the value of the export from Bengal was 1,38,55,770 R. In 1906 it was 3,14,82,409 R., and yet the actual difference in quantity exported was only between 204,072 cwts. in 1896 and 271,101 cwts. in 1906. The total export from India in 1906 was of the value 3,31,39,706 R.

It must be realized that all these facts concerning the life history of the insect are of the greatest importance. If the government is to extend successfully the lac industry it must ascertain them before it can know the best time and methods of propagating the insect and the proper trees on which it can thrive. Many absolute failures in promoting lac cultivation in the past were entirely due to ignorance of these facts, as, for instance, mistaking the swarming of the male insects for the swarming of the larvæ. During the past two years considerable research and elucidation of the problems of lac cultivation has been done

* Knowledge and Scientific News.

in India, and it is now suggested that the industry might be greatly furthered by forming forest villages inhabited by people who could do the little grain cultivation necessary for their own small needs and devote the rest of their time to such forest work as lac cultivation.

Finally, the summing up of the official report is interesting: "It will have become abundantly evident that, with the exception of the Central Provinces, the department has not realized the immense value of lac as a minor forest product. . . . The position has to be faced that the cultivation of the product on scientific lines is not understood. But little advance has been made in the production of the substance since the days of Akbar, and the daily increasing demand for the product of which India is the chief producer would seem to necessitate considerably more attention being paid to its collection than has been the case in the past. . . . There appears to be small reason to doubt that money expended on this work will yield very large returns."

A PROFILE PUPPET-SHOW.—III.*

HOW IT CAN BE MADE AND USED.

BY A. ROZE.

Concluded from Supplement No. 1796, Page 366.

FIG. 11 is a clown on a comical spotted horse. This is composed of eight different parts—four legs for the horse, each leg being in one piece, then the head, next the body of the horse, and the clown, the arms being movable, as in Fig. 10. Three life-lines *A* only will be necessary for this figure. Attached to a simple crutch, then moving the crutch forward and backward from left to right, some most grotesque movement can be got.

Fig. 12 shows a trick figure, a nice plump little gentleman, evidently on his way home, with something in the bag for breakfast. One crutch *A* only is required for this figure. See Fig. 13. After the figure has hobbled and danced, he suddenly grows taller and taller, and becomes himself again. Then his neck becomes four times its usual length; again he grows tall, and at the same time his neck lengthens. This will prove a very funny figure. See the back view of figure; the legs are arranged so that they slide up and down freely through a slip of cardboard glued to the figure, which keeps them in position. The legs are prevented from falling out by a piece of wood which is glued on at *D*. The neck is arranged in the same manner; a piece of wood is fixed at *E*. To work the figure, bring it on as a dwarf, the crutch being in the left hand. Then by raising both life-lines *F*, each attached to a boot-button *G*, thus will raise the figure, allowing the legs to drop and lengthen out. Next a line *H* is fixed to the hat, the upper end above crutch having a button *I* tied on. This will raise the neck. A few minutes' practice and you have the giant or dwarf at will.

Last, but not least, is a Pierrot troupe of entertainers. The manipulators for this set should sing one or more ballads and humorous ditties for each figure. The back view (Fig. 15) shows the mechanism of the figures, the threads being only seen and worked at the back and the figures in front, as in Fig. 14. The seat and bodies of figures and piano are cut in one piece, the movable legs, arms, and heads being separate pieces. The movements and working are shown by Fig. 15.

The whole set-piece is kept in position (shown by the dotted lines) by a piece of wood, which is shown by the dotted lines *A*, one inch in width, half an inch in depth, and length in proportion, so that the end *B* is out of sight of the audience. *C* is the same piece of wood, but brought forward and enlarged.

To illustrate the method of working the figures, each has a screw-eye devoted to it, through which threads other marionettes, with the exception of the arms of No. 1 at *F*, also the head *H*, and the hands of pianist, *H H*, which have an eccentric motion, explained in Fig. 16, which is the head of Fig. 14. *A* is the body, *B* the head attached to body by wire *C*. Next, a horseshoe-shaped piece of stout cardboard is glued on the back of the head, as shown by *D*. The head can now be made to rock to and fro, kept in its right position by the wooden button *E*, which is glued on to the body, and of such thickness that it will catch the horseshoe *D*, whichever way the head moves. To bring the head back to its original position, a counterweight may be required. This is done by gluing a piece of wood to the back of the head, and on opposite side to the thread. This mechanism acts also for the arm of Fig. 15 at *F*, for the tambourine arm No. 4, also for the hands of the pianist. The joining of the other parts—legs, arms, etc.—is done in the same manner as for the single figures.

To work the troupe, each figure is controlled by its own threads terminating at *C*, where the buttons are pulled. The whole of the figures can be worked at the same time by manipulating all the buttons at once; but to work in proper order, suppose No. 2 is singing a ballad about "beautiful spring," he only lifts occasionally his music up and down, the pianist accompanying him. The principal threads are hidden from the view of the audience; but the ends of some threads are in front view for the Pierrot No. 2 with music. The thread is passed through a small hole at *X*, made by a needle, then fixed to the music. It will be seen, when the thread is pulled, that it will raise music and work the arms, the latter being firmly attached to the sheet of music. All the other figures, when the thread passes through to the front, are arranged in the same manner.

The drawings illustrating this series, if carefully studied, will help the amateur entertainer safely through his work. Color the figures to fancy, using bright colors, and in some give various shapes and designs of bright tinsel paper, thus making a smart and attractive show. A little appropriate music to accompany the figures will make the performance complete.

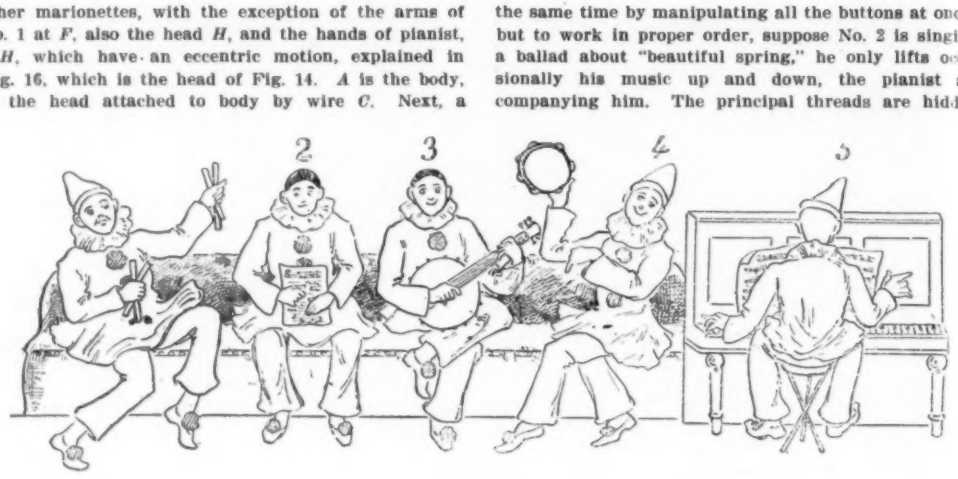


FIG. 14.

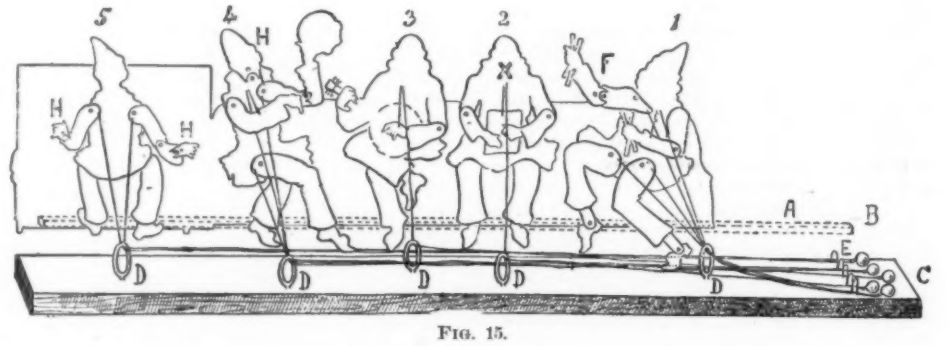


FIG. 15.

FIG. 11.

FIG. 12.

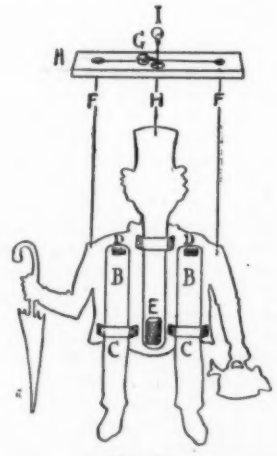


FIG. 13.

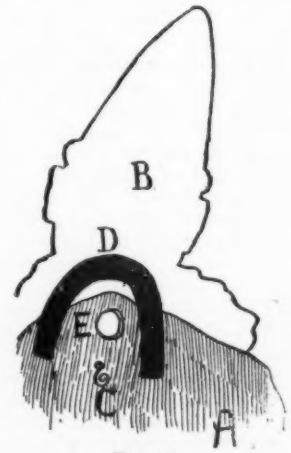


FIG. 16.

* English Mechanic and World of Science.

THE MANUFACTURE OF GLASS.*

SCIENTIFIC DEVELOPMENTS IN THE GLASS INDUSTRY.

BY DR. R. SCHALLER.

THE manufacture of glass involves first the chemical process of producing glass from the proper raw materials, and secondly the mechanical art of fashioning the molten glass into the multitude of articles for which the market calls. The mechanical aspect of the industry was early developed to a high state of perfection. It is only within comparatively recent times, on the other hand, that the chemistry of glass making has been worked out with scientific method. The need for such a development first made itself felt with special force in connection with the manufacture of optical instruments, and it is largely this circumstance which caused the famous Jena Glass Works to undertake the systematic study of the physical and chemical properties of glass.

The influence of the composition of glass on its properties is best brought out by a graphic representation. Thus in Fig. 1, distances measured off to the right, along the axis of the abscissæ, represent the composition of a soda glass, while the corresponding ordinates represent temperatures. The curve drawn out in a full line shows the upper limiting temperature of devitrification. This means that a soda glass of a given composition remains glassy provided it is not cooled below that point on the curve, which corresponds to the particular composition of the glass. Thus for example a glass containing about 75 per cent of silica (SiO_2) and 25 per cent of soda (Na_2O) can be cooled to nearly 700 deg. C. without devitrifying. The significance of this curve is obvious when we consider that in working the glass it must be brought down to a temperature at which it possesses a sufficient degree of tenacity. The dotted line on Fig. 1 indicates points of equal tenacity. It will be seen that at temperatures corresponding to this particular tenacity, glasses of certain compositions are below the temperature required to keep them from devitrifying. They cannot therefore safely be cooled down to this degree of tenacity. Others, in a small region extending about from 71 to 76 per cent SiO_2, are above that temperature, and will therefore remain glassy if cooled till they have the tenacity corresponding to the dotted line.

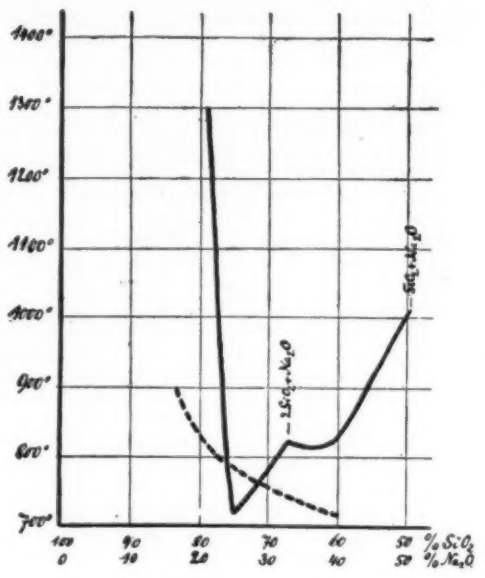
The pure soda glasses can not be used for the general purposes to which "glass" is put, as they are water-soluble. The second diagram shows some of the properties of a lime-soda glass, such as we have for example in window glass. In this diagram the ordinates represent the proportion of soda (Na_2O), and the abscissæ proportion of lime (CaO). It is understood throughout that the proportion of silica (SiO_2) is 100. The lines drawn out in full are lines of equal stability, the numerals 2, 3, 5 representing increasing degrees of instability. The dotted lines correspond to equal temperatures of devitrification. The compositions suitable for window glass are those comprised within the field bounded below by one of these dotted lines, and above by one of the full lines. For if we step outside this region, either the temperature of devitrification is too high, so that the glass cannot be cooled down to a working temperature, or else the glass is too unstable.

In addition to lime and soda, many glasses contain also alumina or boron trioxide. The effect of these constituents is to increase the stability of the glass. In the case of alumina this is probably due to the formation of double silicates of the type of felspar. The beneficial influence of the boric oxide is probably due to another cause: this body functions as an acid, setting free silica.

As has already been pointed out, the physical and chemical investigations at the Jena Glass Works were in the first place aimed chiefly for the production of new optical glasses. All the glasses known in the earlier days were somewhat similar in their optical properties. That is to say, while their refractive index and dispersive power varied within certain limits, they ran parallel throughout, so that if the known glasses were arranged in order of increasing refractive index, this would at the same time place them in the order of their dispersive powers. Glasses were needed which should not conform to this order, and it was found that especially barium and zinc possessed in a high degree the property of imparting to glass a high refractive index, accompanied by a comparatively low dispersive power.

Another problem was to prepare crown and flint glass which would give as nearly as possible similarly proportioned spectra. The flint glasses then known gave a spectrum which was much more drawn out in the blue than that produced by crown glass. The remedy was found in the addition of boric oxide, which foreshortens the blue end of the flint-glass spectrum.

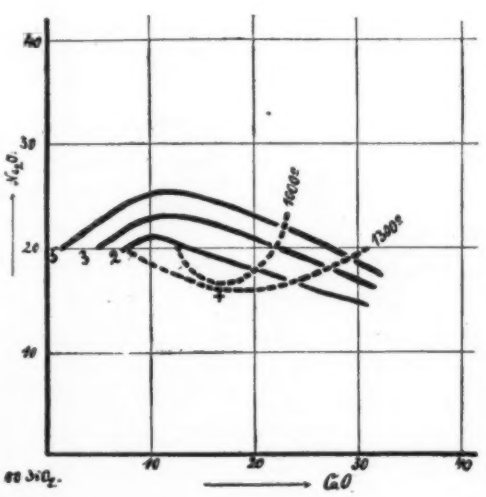
Another class of optical glasses are the colored glasses. The principal problem in the preparation of these is to produce as nearly as possible ideal color filters. Such a glass must absorb as completely as possible some particular portion of the spectrum, while transmitting the remainder. The materials added to give the requisite color are the oxides, sulphides and selenides of certain metals, or in certain cases the metal itself in a highly divided state. The color imparted by such additions depends in part on the composition of the glass in which they are dissolved.



Upper limiting temperature of devitrification.
Curve of equal tenacity.

FIG. 1.

A problem of the same character is the preparation of glasses which transmit very short wave lengths of light. It is well known that quartz and boric acid have the property of being transparent to ultra-violet rays. The presence of metallic oxides more or less completely destroys this property, the extent to which this takes place depending on the nature of the metal, thus sodium has a stronger effect than potassium,



Curve of equal stability.
Curve of equal devitrifying temperature.

FIG. 2.

while lead glasses are particularly opaque to short wave lengths. However, by carefully observing certain precautions, it is possible to prepare silicate glasses of much greater transparency to ultra-violet light than common glass. A special product of this character made by the Jena works and marketed under the name of "uviol glass" has found application especially in astro-photography and in the manufacture of the uviol mercury lamp. This latter, as our readers may remember, is used for medical purposes in the treatment of skin diseases, and in certain chemical industries, especially in the production of linseed oil products.

Another property of glass which is of great importance in connection with certain of its applications is its behavior toward changes of temperature. If a hot glass article, while still soft, is allowed to cool quickly, inequalities in density are produced within the mass of glass, giving rise to internal strains. A glass tube, for this reason, is always under a peripheral compressing strain, while the inside is under tension. The consequence of this is a high resistance to mechanical injury on the outside, while any scratch on the inside, especially in the case of thick walled tubes, almost inevitably leads to the cracking of the tube. Such tubes in which the outer wall is under a compressing strain and the inner wall under tension nevertheless possess certain advantages over tubes free from strain. For if such a tube is heated from within to a temperature considerably exceeding that of its surroundings, the thermal expansion of the inner layers must first neutralize the existing tension before the tube can acquire any tangential expansion strain tending to burst the tube. Such a tube can therefore withstand considerably higher differences of temperature between its inner and outer surface than a tube initially free from strain. The same advantage is gained where the tube is to be subjected to pressure from within, as in water gages for boilers. For this purpose tubes free from strain cannot be used at all. The sensitiveness of the inner wall may be prevented by making the tube of two layers having a different coefficient of expansion with temperature. Tubes of this kind are largely employed for boiler gages.

A glass having a very low coefficient of expansion will cool without acquiring any appreciable strain. Such a glass is particularly well adapted to resist sudden temperature changes and is used for example in making chimneys for incandescent gaslight. Another purpose for which glass possessing special properties is required is the construction of thermometers. One of the errors to which thermometers are subject is the apparent lowering of the freezing point if the latter is observed soon after the thermometer has been used to measure a high temperature. Experiments showed that the simultaneous presence of potash and soda is particularly responsible for a large error of this character. Finally, the brand known as Jena normal thermometer glass 16 III was evolved, and this is now regularly manufactured in uniform quality. It is commonly formed with a red streak to render it readily distinguishable. Its coefficient of expansion is so nearly alike to that of platinum that the metal can be fused into it, making a gas-tight joint. Another special thermometer glass is the boron glass 59 III, which is particularly well adapted for high temperature thermometers ranging up to 500 deg. C. This glass is even superior to the first mentioned, having a lower coefficient of expansion. This, however, brings with it the disadvantage that a gas-tight joint with platinum cannot be made through it by fusion.

In conclusion it may be said that the principal characteristic of the advances made at the Jena works during the last twenty-five years consist in the production of special glass adapted for definite purposes. This was rendered possible only by greatly increasing the variety of types of glass prepared and by the utilization of elements which previously had not been employed in glass making. Nevertheless, had the demand been exclusively for glasses for scientific purposes, this would never have been sufficient to enable the manufacturer to meet the requirements and at the same time secure a margin of profit. The commercial possibility of the developments which have taken place necessarily rested on their exploitation for general technical purposes, as for example in the manufacture of the Jena incandescent gas-light chimneys.

Patina.—The modern bluish imitation patina on lamps, etc., can easily be produced by means of a varnish paint prepared by stirring together copper carbonate and a very light colored spirit varnish (sandarac or shellac solution). Verdigris alone, used in the same way, gives a pale green patina; mixed with copper carbonate, it gives the medium tones.

* Abstracted from a paper read before the Verein deutscher Chemiker at Frankfort, a. M.

COMMERCIAL MOTOR VESSELS.

THE SUCCESS OF THE MARINE INTERNAL COMBUSTION ENGINE.

IF there are still any skeptics who cannot see a future before the internal combustion engine for marine propulsion, the list attached to the paper read by Mr. Linton Hope at the Naval Architects, giving details of 120 commercial craft fitted with this form of power, should prove sufficiently convincing. Such a collection of data, drawn as it is from various sources, and embracing vessels of various types, is valuable as giving the same sort of indication as a thermometer, which, by abstracting a portion of the heat from the body tested, measures the intensity of it. There must be at the present time in various quarters of the globe several thousands of vessels propelled either wholly, or as an auxiliary, by internal combustion engines, and the number is growing daily. The question now is not whether motor-driven vessels have come to stay, but how fast development will proceed in the larger powers which have hitherto been considered outside the practical limits for oil or gas engines. Though for many years past the possibilities of the high-speed motor have been recognized and made use of in racing craft and other high-speed small vessels, we shall be probably justified in saying that the stoutly built moderate speed motor suitable for the rough-and-tumble work in commercial craft hardly existed ten years ago. To-day its existence is officially recognized by the recently issued regulations of the Board of Trade requiring certain qualifications from the men in charge of such engines, similar to those required from those in charge of steam machinery at sea.

The industry which has thus emerged from its embryonic state has had its share of infantile troubles. At first there was too much tendency slavishly to follow the ideals of the engine as used for road work, and the phrase "only a motor car engine" became a by-word to describe unsatisfactory marine installations. For this state of affairs marine engineers may be partly to blame, for with the conservatism which usually characterizes those that go down to the sea in ships, they looked askance at the advent of a form of power which claimed to be able to supersede steam, and, speaking generally, though there are notable exceptions, they gave it neither advice nor encouragement. Experience, however, soon showed that the high speeds of revolution were unsuitable for marine work if reliability were made a first consideration. For boats which are intended merely as racing machines speeds may be high and weight cut down to the narrowest margin. If the engine fails during a race it is just towed back, probably by a steamboat, the deck hands of which leaning over the side with arms on the rail deliver themselves in true nautical style of caustic comments and opinions on the unfortunate motor boat astern. The commercial marine motor must be in an entirely different category. Unlike the road engine, the highest speed and the heaviest load occur together, and the margin of reliability must, therefore, be very ample. For this reason excellent engines for shore purposes may be unsuitable in vessels. Whatever merits they possess may be entirely annuled by a single weak spot, the failure of which may be unimportant on shore, but which by causing a stoppage of the engine at a critical moment would be productive of disastrous consequences at sea. Speed of revolution is one of the elements of reliability, and speeds are being reduced not only from this reason, but also because of the difficulty often found in getting an efficient propeller for the higher speeds. This has been noticed in the case of several of the East Coast herring drifters which have been fitted with oil engines. The speed in some cases is up to expectation in smooth water, but in a number of cases it is found that the motor has little effect in driving the boat against a head sea. Nor is this surprising when we consider that the drifter propelled by the oil engine has a much higher speed propeller with a disk area of only about a fourth that of the steam drifter.

We know now from recent turbine experience that high-speed propellers need not be inefficient, and that an important factor is the position of the propeller relative to the hull. In many of the fishing boats the propeller is so small as to be largely masked by the dead wood, and it cannot therefore get so good a supply of water as it should for maximum efficiency. Twin screws, if admissible on other considerations, would go far to meet the case, but failing this expedient the speed of revolution should be largely reduced from that which now generally obtains, though there is no necessity to reduce to the same low level as that at which the steam drifter runs. The reduction of revolutions means, of course, a larger and more expensive engine, but the benefits already derived from the use of power in these fishing boats indicate that the increased speed and efficiency to be obtained by slower running engines will amply repay any extra cost entailed.

It is desirable that the idea should be abandoned that because an engine is labeled a motor it therefore must run at a high speed. The speed of the motor must be subservient to the purpose for which it is required. This has been recognized on the Continent, where the oil and gas engines, which have been fitted in large numbers for canal and river work, are invariably of the slow or moderate speed type. With moderate speed engine, there is still a large margin of saving in weight to be made over steam machinery of moderate power, though it is now generally accepted that the margin will be less as the power increases. There is thus everything to gain, weight and economy of running and upkeep, by extending the use of motors in vessels requiring powers up to two or three hundred horse-power. Beyond that we are as yet in the dark as to possible developments, but there is still a very large field in fishing boats, small trading and coasting vessels, requiring power up to this limit. Unfortunately for rapid progress, this class of business is generally in the hands of men of relatively small means, who cannot afford to experiment, and the brunt of the pioneering expenditure will have to fall on the makers of the engines. It is also fairly evident that it will be wise to wait the results of experience in the moderate sizes before proceeding to the powers required by the ocean tramp. It is generally conceded that when we pass the limit of about 200 horse-power, the ordinary reversing arrangement by friction clutch and gearing, which may be made quite satisfactory up to those powers, will have to be superseded either by making the engine reversible or interposing a reversible transmission such as an electric dynamo and motor. The possibilities of gearing down must also not be overlooked, as this allows the speed of the engine to be kept up, and the turning moment of the engine shaft may remain such that friction clutches and gearing may still be employed. All these schemes will, no doubt, in time be tried, and equally, without doubt, the fittest will survive. When the line of development of the larger-sized engines has been determined there will be found an enormous field for their application. There are the steam trawlers, for example, which are of higher speed and engine power than the drifters, and present also some pretty problems for the application of the internal combustion engine to the auxiliary appliances with which they are fitted, such as the refrigerating machinery, steering engine, and windlass. It is notorious that these vessels earn a dividend with difficulty, and the difference between a small dividend and none at all may be made by a shilling a ton on or off the price of coal. These trawlers now go so far afield that the reduced consumption of fuel will be of considerable advantage in giving them an increased radius of action besides the direct advantage of economy. We are still yet a little way off from the commercial marine motor of 500 horse-power and above, but in the meantime we have learned much from what has been done already, and the way is steadily being prepared for further developments.—The Engineer.

THE LIBERATION OF ELECTRONS DURING CHEMICAL REACTIONS.

THOSE who retain their doubts as to the real existence of electrons may be interested in the account of some experiments by F. Haber, G. Just, and F. W. Robinson, of Karlsruhe, described in the Zeitschrift für Electrochemie. Metals are supposed to be rich in electrons (negative particles) which are credited with playing an important part in the conduction of electricity through the metals, while metallic oxides are said to be devoid of electrons. The electrons might, therefore, be lost during chemical reactions between metals and other elements; and if the other element were a gas, that gas should assume a negative charge, and the current of gas should, so to say, blow the escaping electrons away from the surface of the metal. It occurred to Haber to study this phenomenon with the easily-oxidized alkali metals, which were applied in the experimentally more convenient form of amalgams. Potassium-sodium amalgam was made to drip from a glass funnel, the concentration of the amalgam (which will be more or less liquid according to its percentage of mercury) being such that about four drops fell per minute. The drops fell within a cylinder of platinum gauze which was charged from a battery, as a rule, to 22.5 volts. A current of gas was passed through the cylinder, and the whole apparatus enclosed in a black box to shut out all light which would itself have an ionizing effect. In spite of all precautions the platinum gauze slowly lost its charge owing to the difficulties of maintaining perfect insulation; a loss of 1.5 volts took about 4 minutes with a positive charge of the gauze, and 6 minutes with a negative charge, in a chemically indifferent atmosphere of pure nitrogen or hydrogen. When the atmosphere contained gases which would react with the alkali metal—viz., oxygen, iodine, etc.—the loss was much more rapid, taking a few seconds. The loss of the charge was, therefore, not merely an effect of frictional electricity; there was friction between the gas current and the metallic surface. It was, moreover, observed—and this is the chief point—that only the positively-charged gauze cylinder was discharged, not the negatively-charged, so that the particles concerned must be electrically negative particles. The experiments were made first with indifferent gases, and then with gases containing also water vapor, oxygen, and other constituents, such as would react with the alkali metal. The complete drying of a gas is, of course, an exceedingly difficult operation, and in view of the researches of Brereton Baker, it would be most interesting to ascertain whether any liberation of ions and reaction would result in a perfectly dry atmosphere; that was impossible, however, with the somewhat complicated apparatus. But the observations of Haber were checked in various ways. When the nitrogen or hydrogen was pure, the surface of the amalgam remained bright; in the presence of water vapor or oxygen it became dull, owing to the formation of an oxide film, and in that case the rapid discharge was always noticed. Interference colors—yellow, red, green, depending upon the thickness of the film—were also observed; and light likewise produced a discharge. Among the active gases tested were hydrochloric acid, iodine vapor (which was inactive at 79 deg. C. (—61.7 F.), when any vapor originally admitted into the tube system would be condensed again before reaching the amalgam), thionylchloride (also inactive at low temperature), and phosgen. Thus the conclusion appears to be justified that a current of chemically active gas liberates electrons which produce a loss of a positive, but not of a negative, charge. This conclusion is not in accord with similar experiments of G. Reboul, first brought before the Paris Academy of Sciences in 1908; the experiments of Haber began later. Reboul observed a loss of both positive and negative electric charges during certain chemical reactions. But it would appear that he did not take particular pains to start with pure metallic surfaces, and that he would thus overlook the unipolar character of the phenomena occurring during the first stages of his experiments.—Engineering.

In the Comptes Rendus Robin describes the phenomena of the extinction of sound in iron. A rod of iron suspended from a point near a vibration node gives a musical sound when struck, accompanied by a feeble deep hollow note in bars of sufficient length. The first-mentioned sound is produced most distinctly when the rod is suspended at a point about one-quarter or one-third of its length from one end. A comparison of the notes given by five very pure steel bars of similar dimensions and differing only in the proportion of carbon present, showed that the pitch varied inversely as the proportion of carbon. The differences are feeble, but their detection is aided by the usual manifestation of beats when two rods are set in vibration near one another. When the temperature is increased, starting from the ordinary temperature, the pitch of the note diminishes in a regular manner and the intensity of the sound becomes rapidly less, disappearing altogether just below 100 deg. C. in the case of iron and steel low in carbon. When the temperature is further raised, the sound reappears at about 150 deg. C., grows to a maximum and vanishes again at a dull red heat. This anomalous variation of the intensity of the sound with the temperature appears to be characteristic of iron and possibly of nickel. The range of aphony varies according to the amount of carbon. With 0.2 per cent of carbon it is complete between 95 deg. and 147 deg. C.; with 0.45 per cent of carbon it is complete between 85 deg. and 120 deg. C. In the case of a steel containing 1.3 per cent of carbon and containing cementite, the intensity of the sound remained approximately constant from the ordinary temperature up to red heat.

THE MALLET LOCOMOTIVE IN SERVICE.*

THE PERFORMANCE OF A WONDERFUL ENGINE.

WHEN it is claimed, or even suggested, that a Mallet articulated compound locomotive can be maintained as cheaply as an ordinary simple engine of half its capacity, the statement must be attributed to enthusiasm or ignorance. The Mallet is, to all intents and purposes as far as repairs are concerned, two complete and independent locomotives with the exception of the boiler. That it should be possible to maintain these two engines as cheaply as one does not stand to reason and is not borne out in practice. Records show that a Mallet costs something more than twice as much per mile run for repairs as a consolidation of about two-fifths its tractive effort. The saving in repairs on two boilers is offset by the expense for the extra parts, such as jointed receiver and low-pressure exhaust pipes. To put the matter definitely, it costs about 23 cents per mile for repairs on heavy Mallets, as compared with from 7 to 10 cents for consolidations of less than half the tractive power, and they are out of commission from 20 to 25 per cent of the time.

Still, they are economical where a heavy power is required and they can be made to take the place of two lighter engines. They cut the wages in two, and the compound feature effects a saving in coal of from 15 to 20 per cent per horse-power produced; the repairs drop to about 2 cents per 1,000 ton-miles instead of 3.5 cents with heavy consolidations. From an operating standpoint, also, it is very evident that one engine is better than two, especially if it can be handled as readily as one of the smaller units, and this is the case. The largest of the Mallets can be spotted as easily as any smaller engine and may be handled with any desired degree of delicacy.

Whether it will be possible to extend their radius of action from short pusher runs to regular road service is quite another question. It is all very well to assert that they are free steamers and that the fireman has no difficulty in holding his pressure, which is quite true in limited action. An engine that carries a pressure of from 200 to 215 pounds may be held up to the blowing-off point over the average pusher grade, and, using some latitude in the phrase, "without difficulty." But this is very far from saying "without exertion," for it does require an exertion of the most strenuous kind. No one who has seen the work done by a stalwart fireman in taking one of these engines up eight or ten miles of a 1 per cent grade would care to wager on his ability to maintain the pace over a division of from a hundred to a hundred and fifty miles. When working to its full capacity one of these big fellows will evaporate 7,000 gallons of water an hour, which means that about four tons of coal must be shoveled.

With the slow speed that usually obtains the footplate is steady and there are no surges of the machine to add to the labor. The constant shoveling is interrupted only by raking and leveling, and without an interval for the taking of breath. The rate of combustion must be kept at the highest pitch and the heat from the opened door is scorching in its effect. It is here that the mechanical stoker becomes a necessity if the run is to be extended to cover a division. There is but one mitigating circumstance in its use for road service, and that is, under ordinary conditions, the engine would not be crowded so hard continuously. In pusher service the reverse lever is dropped down in the corner and left there; whereas on a road run it would be hooked back, easing off on the consumption of steam per revolution, but probably requiring quite as rapid a rate of evaporation per hour.

Of course, where oil is used as a fuel the whole situation is changed and the physical strain on the fireman is avoided and the suggested limitation of the radius of action does not exist as far as the man is concerned, but it remains to be seen whether a locomotive boiler can be built within available dimensions that can meet the evaporative demands of a big Mallet when pulling a heavy train at road speeds.

As for the action of the engines upon the track, it appears that they have lived up to the claims made for them by their designers. While it is not known as to just how they distribute their lateral stresses upon the track, any more than it is of other locomotive types, still where one Mallet has been substituted for two or more consolidations on a pusher grade, the wear of the rails has been lessened, from which it has been inferred, whether rightly or not cannot be stated, that these new locomotives are easier on the track.

Mallet locomotives are capable of making from 30,000 to 40,000 miles between general repairs, and in some instances the latter figure has been exceeded. An examination of the 0-4-4-0 locomotives that have been out of the shop for four months shows that the tires are in remarkably good condition. There is no perceptible flange wear on any of the wheels, except the leading pair of the front engine, which show a decided tendency to run sharp. This is probably due to the fact that the engine is working hard when run forward, as half of the mileage is made when running backward light.

The internal resistances of the engine are somewhat higher than those of the ordinary types. A Mallet locomotive will not drift down a 1 per cent grade. An Atlantic would attain a high speed in such a place and a consolidation would run faster than would be allowable; whereas steam must be used with the Mallet in order to get down at all. As to what percentage of the total power developed this amounts to, accurate data are not available, but when added to that required to raise the weight of the engine and tender up the grade it must be a goodly proportion of the drawbar pull available at the back of the tender.

Again, the wear of the connections between the front and rear units seems to indicate that there is not always that harmony of action between the two that is to be desired. It may be the effect of imagination, but there seems to be a surging action when the engine is at work, closely resembling that felt on ordinary engines when they are not properly counterbalanced. This is especially noticeable on the firing platform, but is scarcely perceptible in the engineer's cab except when running light. Unless the connections are made far stronger than any calculations would indicate to be necessary, there is apt to be a breakage and a separation of the castings. When the engine is pushing, the action is not so apparent, for then the front unit is pushed back by the load and the after one tends to run up on it, so that the two are brought together; but when pulling, the forward unit can surge away from the rear one with the full force of the maximum power that it can exert. This movement is especially noticeable when the engine is running light. It ought to be met by putting an excessive strength into the connecting parts.

Very little leakage occurs at the ball and expansion joints of the receiver and exhaust pipes, and no serious trouble has been experienced. Evidently the designers looked upon it as a place requiring especial attention, and by giving it have obtained very satisfactory results.

The cab must necessarily be one-sided. As the fireman is away in the rear, and communication from one side to the other is out of the question, everything must be on the right-hand side; this includes the throttle and reverse levers, two injectors, two cylinder lubricators, two sets of cylinder cock levers, two sanders, engineer's brake valve and straight air-brake valve, water glass and cocks, whistle and bell cords, steam valves for oilers, and emergency valve for converting to simple action. With the wide firebox and the limited space available, there is not much left for the man when all of these appliances are in place. Still the arrangement is quite convenient, and because of its air reversing gear the engine is easily handled.

Under ordinary conditions of service the emergency exhaust of the intercepting valve is rarely opened, even when starting a heavy train. There is usually enough slack to be obtained for the high-pressure cylinders to exhaust once or twice before the full load comes upon the engine, and then the low-pressure unit is at work.

Hence, whether the Mallet is regarded from the standpoint of the mechanical, operating or track departments, or of the engineer in the cab, the locomotive must be considered a very satisfactory machine. The only man who has serious objections to it is the fireman, who is called upon for such strenuous exertion; for him the mechanical stoker ought to solve the problem, and thus relieve him of what seems to be an impossible task.

* From Railway Age Gazette.

CHAINS FOR POWER TRANSMISSION.

IN an interesting paper read by Mr. A. S. Hill before the Incorporated Institution of Automobile Engineers, on the use of chains for power transmission, the author, according to Engineering, gives the history of the different kinds of chains now used for driving purposes, with a description of the methods adopted in their manufacture. As is well known, great advances have been made during the last few years in the design and workmanship of these appliances. Ewart's type of detachable malleable iron chain for conveyors and similar purposes has for long been known, and has had a very wide application; but it is probable that the production of a really satisfactory chain for driving purposes has been due to the demands of the cycle trade, perhaps the greatest advance in this line being made by Mr. Hans Renold, who introduced his roller-chain in 1880. This was, of course, but the commencement; but from it the present excellent chains of this class may be traced. A standard ½-inch pitch roller chain of to-day weighs only from 3 ounces to 4 ounces per foot, has a breaking strength of 2,000 pounds, and will run up to a speed of 800 feet per minute, at least, with satisfactory results. The accuracy of these chains is remarkable, as may be realized when we consider that one of them, 56 inches long, contains 560 different parts and 112 joints; a limit of 1-32 inch is guaranteed in the length, or an average limit of 0.0003 inch per joint. The roller chain has now largely superseded the block-chain, which used to be applied to all bicycles and which gave satisfactory results for speeds up to 600 feet per minute. In the early days of motor-cars the block-chain was universally used as a means of transmitting the drive to the wheel. It was, however, afterward replaced by the roller-chain. Single roller-chains have a remarkable wearing power, as is proved by the fact that they have lasted remarkably well on automobiles working under very unfavorable conditions. Mr. Hill considers that although they have largely been replaced by the use of the live axle, which forms a clean, well-housed piece of mechanism, there is still something to be said in their favor. They have a higher efficiency for transmitting power than high-reduction bevel or worm gears, and also possess more flexibility. They are also fairly accessible even when inclosed in cases. Another advantage claimed for them is that they do not place so much weight on the parts not supported by springs as do live axles. The inverted tooth type of chain has in many cases taken the place of the roller-chain, particularly where large powers have to be transmitted. It was originally designed to transmit higher powers than the roller-chain, and has become very popular, and is now much used in connection with motor drives and high-speed engines. Its great advantage is that its links take a bearing on the face of every tooth with which the chain engages; and as the pitch of the chain increases, due to wear, the chain ascends the angular faces of the teeth, and assumes automatically an increased pitch circle and accommodates itself to the wheel. All the teeth also in the arc of contact transmit the same power independently of any increase in the pitch due to wear. The author states that there is now a chain of this type being manufactured which is 18 inches wide, with a pitch of 2¼ inches, and will transmit 350 horse-power. The chief advantages of a chain-drive are: That the drive is positive; it has a high efficiency; tension is not necessary to make the chain grip the wheel, as is the case with belts; there is a minimum of journal friction, and, in the case of inverted teeth, compared with other forms of tooth-gearing, the drive is very noiseless. These, no doubt, are advantages well worth consideration.

Discussing the question of the weight of motor cars, the Autocar states that there is no such thing as absolute rigidity, and the most scientifically built car is that which provides just that natural amount of spring and give in the structure, as a whole, which is desirable, and at the same time does not contain a single part which is insufficiently strong for its work. Anything more than this means the carrying of needless weight, which in its turn not only results in unduly rapid wear of tires, but also means slow climbing, lack of liveliness, and waste of petrol. On the level and downhill, so far as speed is concerned, weight is no advantage. Speaking broadly, it may be said that the heaviest cars in proportion to their power are the smaller ones, as many of these are almost as heavy as cars of considerably higher power. At first glance it would appear that either the smaller cars are needlessly heavy or that the larger cars are insufficiently strong. However, practice has shown that neither the one assumption nor the other is correct, and that both cars are just about the right strength, and, therefore, presumably of about the right weight for their work. Considering the experience gained and the improved materials now available, it cannot be said that, as a whole, weight has been kept down quite as much as it should have been.

HEREDITY.

Concluded from Front Page.

Heredity has for the stockman and plant-breeder a well-recognized commercial value, because by a knowledge of its laws he is enabled to produce in greater number or with greater certainty animals or plants of a particular type. Indeed, much of our present knowledge of heredity has been derived from a study of the domesticated animals or of the cultivated plants, and from the same sources we may expect to continue to draw, for here alone have we an unobstructed field for observation and experiment, the indispensable tools of scientific research. Just as the sciences of anatomy, embryology, physiology and pathology progressed but slowly so long as the phenomena of the human body alone were considered, but advanced by leaps and bounds when comparative studies on other animals were undertaken, so concerning heredity in man we have learned and can expect to learn but little from the study of man alone, but much from a study of other animals and of plants and from a comparison of the phenomena in the two cases.

the body as a result of use, disuse or other agencies are not inherited, because they have not affected the constitution of the germ-plasm carried within the body.

Weismann's two principles are of fundamental importance to a right understanding of heredity. They are: (1) That the germ-plasm is independent of the body containing it, or, as Weismann put it, that the germ-plasm is continuous from generation to generation, whereas the body dies, and (2) that acquired characters are not inherited.

The hottest biological discussions of the last twenty years have been waged over these two principles and the contest is by no means ended, but year by year the correctness of Weismann's contentions is more generally admitted.

Common experiences support both principles. Thus the independence or continuity of the germ-plasm has been shown from time pre-historic in the practice of castration upon the domesticated animals or upon man. The germ-plasm is localized in particular organs

vidual, whether an animal or a plant, has its beginning in the union of two bits of germ-plasm, an egg cell furnished by the mother and a sperm cell furnished by the father. Whether the union of the germ-plasm takes place within the maternal body or not is quite immaterial; among a great many animals it does not.

The new individual, it will be observed, is dual in origin, and to its dying day it retains a dual nature. For the maternal and paternal contributions of germ-plasm retain a certain distinctness as we shall see, and may in part separate from each other at reproduction.

Each germ-cell (egg or sperm), so far as its contribution to heredity is concerned, stands for a complete organism of its species, bears the potentialities of a complete organism, and under appropriate conditions can develop into such an organism. For this idea we have strong experimental evidence. It has long been known that the eggs of certain species of animals can develop without fertilization, i. e., without

FIG. 9.—A DARK SMOOTH GUINEA-PIG.

FIG. 10.—A WHITE ROUGH GUINEA-PIG.

FIG. 11.—A DARK-ROUGH GUINEA-PIG.

The new combination of characters obtained when animals are mated like those shown in Figs. 9 and 10 respectively.

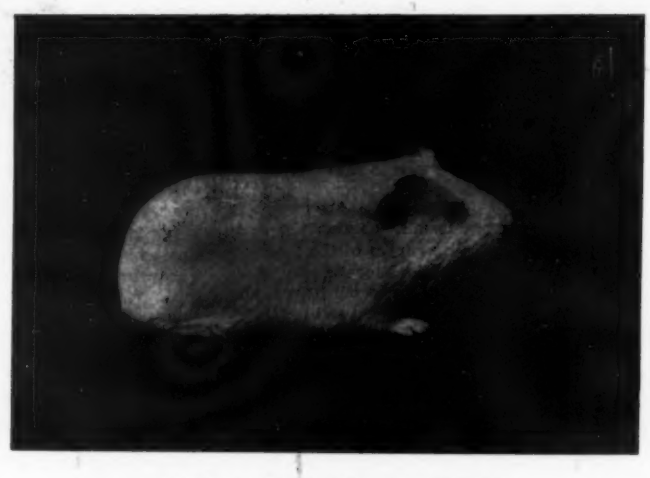


FIG. 12.—A WHITE SMOOTH GUINEA-PIG.

A second new combination of characters, but obtained first among the grandchildren of such animals as are shown in Figs. 9 and 10. Other grandchildren are like the respective grandparents (Figs. 9 and 10) or the parents (Fig. 11).

HEREDITY.

Every new individual arises out of material derived exclusively from its parents. This is the basis of heredity. But it does not follow that the new individual will resemble its parents merely. It may resemble remote ancestors more strongly than either parent. For it represents a combination of materials or of qualities derived from the two parents, and it is possible that neither parent may manifest all the peculiarities which it transmits to the offspring. For the parent is made up of two distinct parts, its own body and the reproductive substance contained within that body, and the two may not be identical in character.

The reproductive substance has been called by Weismann the germ-plasm. He it was who first clearly recognized the fact that the germ-plasm is distinct from the body which contains it, and that the influences which modify the character of the one do not of necessity modify the character of the other. Thus he was able to show experimentally that mutilations of the body, as loss of the tail in mice, are not inherited, and to establish with a considerable degree of certainty the principle that characters acquired by

of the body, the reproductive glands. If these are removed reproduction becomes impossible, though all other functions of the individual persist. Further, it is possible to show experimentally that the germ-plasm transplanted from one individual into another retains the character which it originally had, quite unaffected by the changed body with which it is associated. This Dr. John C. Phillips and the writer have recently shown in the following way. The ovaries were removed from a young black guinea-pig, Fig. 1, and these were transplanted into the body of a white guinea-pig, previously castrated, Fig. 2. The white guinea-pig was now mated with another white guinea-pig, Fig. 3. Normal white guinea-pigs produce only white offspring when mated with each other, but these two have now produced in three successive litters six young, all black. Three of these are shown in Fig. 4. Evidently the germ-plasm of the black guinea-pig retained its original character even after transplantation into the body of a white one.

In order better to understand the processes of heredity we should be familiar with what takes place when a new individual is formed. The new individual

having united with a sperm or male sex-cell. In such cases there can be no question that the potentialities of an entire organism are contained in the egg, for without any outside help the egg develops into a complete individual of the species. In recent years it has been shown that the eggs of many species in which fertilization normally occurs may by artificial means be made to develop without having united with a sperm. This is true of the eggs of sea-urchins, starfishes, and of certain worms and mollusks. Such eggs artificially stimulated to development produce entire individuals, similar to those produced by fertilization, but possibly less vigorous.

On the other hand, a sperm cell may be made to develop, if it is allowed to penetrate into a fragment of an egg, even a fragment which lacks the important cell-nucleus. In such cases the entire nuclear material of the embryo is furnished by the sperm, yet the embryo so produced is complete, lacking no essential part, and similar except in size and vigor to normal embryos produced by fertilization.

Accordingly the evidence is fairly complete that each germ-cell (egg or sperm), considered as the

vehicle of heredity, represents a complete organism, and that an individual produced by the union of two such germ-cells represents twice over each heritable trait of the species. In other words, the germ-cell is single, the individual is double.

This fundamental principle of the singleness of the germ in contrast to the doubleness (duality) of the individual receives the fullest confirmation from experimental breeding.

If we mate a pure-bred black guinea-pig with a white one, the young are all black pigmented. This result seems to violate the principle previously stated that both parents contribute equally in heredity; in reality, however, that principle is not violated. The white parent has contributed its own character to the offspring, but that contribution is unseen in them simply because black hides it. The white will reappear among the grandchildren. In Fig. 5 we see a mother guinea-pig having a jet black coat. Beside her are four young of the same color as herself. The father too was black. In a word this black race breeds true. A female of this race was mated with the albino male shown in Fig. 6. Albinos have white hair and pink (unpigmented) eyes, the red eye color being due to the blood which shows through; they breed true among themselves, but the result is very different when they are mated with black individuals. Two children of the albino male and the black female are shown in Fig. 7. They are intensely black pigmented, as are all the young produced by this cross. Two of them when grown to maturity and mated with each other produced a litter of four young, shown in Fig. 8. Three are black pigmented like the parents, but one is an albino similar in all respects to the albino grandsire. Here we notice the reappearance of the albino character after skipping a generation. The albino grandsire really made a hereditary contribution as regards the character hair color, but it did not show in the children, because black also was present in the children, and black obscured or dominated the white.

Applying our principle of single germ, dual individual to this case, we see that the facts observed are fully in harmony with it. The original cross brought together the character B (black) and W (white) into an individual (or zygote as we call it, a joining together) B W, which showed only black. Two such individuals, a male and a female, were now mated together. In the formation of germ-cells by these individuals there is a return to the single condition, B separates from W and passes into a different germ-cell. Accordingly, the mother forms eggs, B and W, respectively, and the father forms sperms of a like character. Now a new individual arises from a union of an egg with a sperm. Apparently either sort of sperm may unite with either sort of egg which it chances to meet. So there are formed in the next generation three sorts of zygotes (individuals), viz., B B, B W, and W W, instead of B W alone as in the previous generation. The chances for the occurrence of these three sorts of unions are 1 BB, 2 BW, and 1 WW. Any individual containing the character B will be black; accordingly the BWs as well as the BBs will be black and there should be three blacks to one white. These are in fact the observed proportions. The white individual should transmit no other character because it contains only W. Such is indeed the observed fact. Any two white individuals mated together will produce only white offspring. But, if our reasoning is correct, two thirds of the black individuals of this generation (viz., the BWs) should transmit white as well as black, while the remaining one third, BB, should transmit only black. Experiment justifies both these conclusions. If we mate the black animals of this generation, one by one, with albinos, we find that on the average two out of three of them will produce white offspring as well as black ones, while the third one produces only black offspring.

The scientific law which governs the inheritance of albinism, and of other characters transmitted in a similar fashion, is known as Mendel's law. It applies, apparently, to all cases of color-inheritance, as well as to the inheritance of characters of many other sorts. Through its operation new combinations of the peculiar characters of individuals or of races can be obtained in the course of one or two generations. Thus when a guinea-pig showing the two coat-characters seen in Fig. 9, dark and smooth coat, is mated with one showing the combination, white and rough, Fig. 10, young are produced showing a wholly new combination, dark and rough, Fig. 11. And if these young are at maturity bred together, a fourth combination, white and smooth, appears among their young, the grandchildren. See Fig. 12. Other grandchildren manifest the combinations seen, respectively, in the parents and in the grandparents. By selection any one of these combinations may be obtained in a pure race.

Oftentimes a new combination of characters obtained through crosses coincides with a lost racial combination. Then the phenomenon is called reversion or atavism. Thus when yellow rabbits are crossed with black ones, gray offspring are obtained similar to wild rabbits in coloration. There is no longer anything mysterious about the process; it is simple recombination of different unit-characters formerly associated together in the same race, but since isolated in some of the derived races.

Very different in nature, apparently, from the Mendelian inheritance of unit-characters is the result obtained when races of animals are crossed differing in size or in the proportions of their parts. In such cases the children are intermediate in character, and the grandparental conditions do not reappear among the grandchildren. The result may be described as a blend apparently permanent. Fig. 13 shows the skulls of three rabbits, all adult, father, mother and son. The skull of the son is shown between that of his parents, the mother's skull being at the right. Size and proportions of parts are clearly intermediate in the son. No grandchildren were obtained like either grandparent in size. The color of the coat in this same family of rabbits clearly followed Mendel's law, although the size characters blended. The practical result is that one may at will produce a race of rabbits of any desired size within the known limits of variation in size among rabbits, and with any of the conceivable combinations of color factors. Size variation is apparently continuous and its inheritance blending, color variation is discontinuous and its inheritance Mendelian.

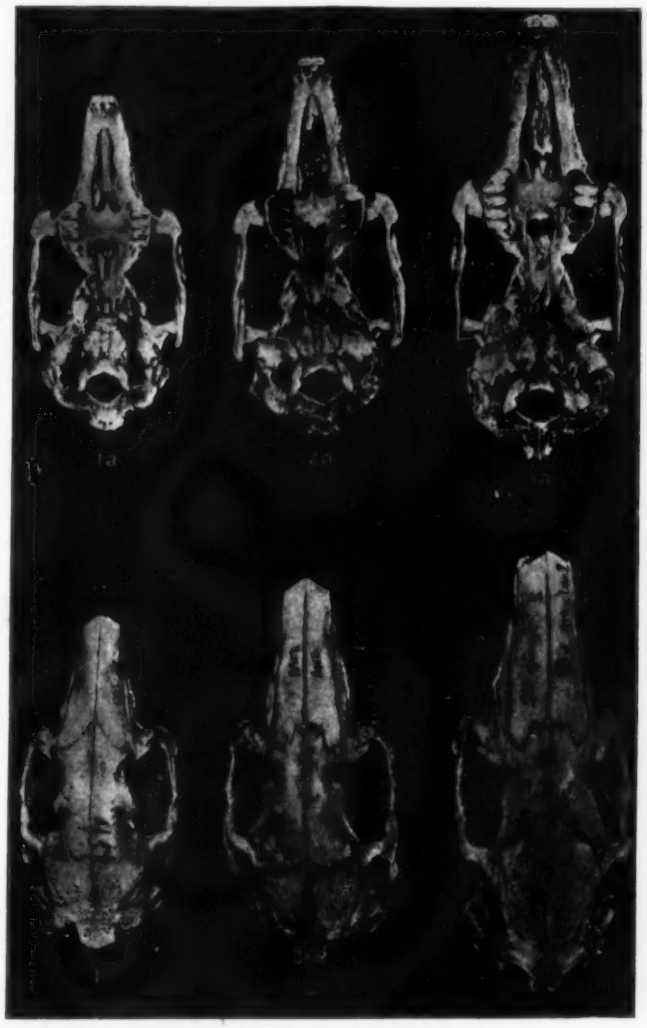


FIG. 13.—SKULLS OF THREE RABBITS.

Mother (3 and 3a); father (1 and 1a); and son (2 and 2a). From publication No. 114 Carnegie Institution of Washington, by permission.

Notwithstanding the seemingly radical difference between these two types of inheritance, it is possible that they may, after all, prove to have a common basis. Blending inheritance may possibly be only a complex sort of Mendelian inheritance, in which many independent factors are simultaneously concerned. The question is one of much theoretical interest. Its solution awaits further investigation.

What has already been accomplished in the study of heredity gives us a hopeful outlook for the future. We are gaining a fuller knowledge of its processes, and a knowledge of processes is a first step toward their control.

HEREDITY.

W. H. Lyon in the Hawaiian Planters' Monthly writes on Pickering's Bordeaux mixture. According to Pickering, the chief aim in making Bordeaux mixture should be to reduce the lime to the lowest possible proportions consistent with the precipitation of all the copper. Comparative experiments have been made with a view to determining the effect of treating sugar cane cuttings with Pickering's mixture. Twelve parallel rows of Lahaina can cuttings (each cutting having two eyes) were planted out. Six of the rows were planted with cuttings inoculated with the pineapple disease; of these six rows, three had had the cuttings soaked in Pickering's mixture for one hour, one in water, and one in normal Bordeaux mixture also for one hour, while the remaining row had untreated cuttings. The other six rows only differed in that their cuttings were not inoculated. It was found that Pickering's mixture injured the cuttings seriously, more than half of the eyes failing to germinate. The inoculated cuttings were much poorer than the non-inoculated ones, thus showing that the pineapple disease was able to enter the cuttings despite the presence of an excess of copper sulphate. The investigation proved conclusively that Pickering's formula should not be used in preparing Bordeaux mixture for the treatment of can cuttings; it also showed that copper sulphate can materially injure or even kill the eyes of can cuttings, so that in preparing Bordeaux mixture for the treatment of cuttings, care should be taken that no considerable excess of copper sulphate is present in the mixture; this can be avoided by the use of a proper amount of lime. The cuttings treated with normal Bordeaux mixture were found to give the best and most rapid germination.

The Swiss Commission appointed to investigate the question of earth as the return circuit in direct-current systems has recently issued its preliminary report. After some introductory tests, the permission of the Lausanne Corporation to run with the earth as the return circuit on the Saint Maurice-Lausanne line was readily obtained, but the railway telegraph authorities noticed disturbances in certain of their lines and so refused permission at first. The difficulty was, however, got over in 1908 by the simple device of inserting a few opposing cells in the telegraph lines affected and so neutralizing the action of the drop in the (constant current) earth return. The arrangement proved so effective that the desired permission was then obtained, and after the necessary batteries had been put into use at four of the stations along the line the earth return service was adopted, and has been in regular use from August, 1908, up to the present time without any interruption. The return circuit can be changed over from "earth" to "line" (a second wire being available) at any time if desired in three or four minutes.

THE CHEMISTRY OF BODY SECRETIONS.

REGULATION OF THE PROCESSES OF THE BODY.

BY PROF. WILLIAM H. HOWELL, JOHNS HOPKINS UNIVERSITY.

AT the time of Sir Charles Bell, physiologists were beginning to realize the great importance of the nervous system as a mechanism for regulating and co-ordinating the varied activities of the body. To use his own expression, "The knowledge of what is termed the economy of an animal body is to be acquired only by an intimate acquaintance with the distribution and uses of the nerves." Since his time experimental investigations in physiology and clinical studies upon man have combined to accumulate a large fund of information in regard to the regulations and correlations effected through nervous reflexes. No one can doubt that very much remains to be accomplished along these same lines, but in recent years we have come to understand that the complex of activities in the animal body is united into a functional harmony, not only through a reflex control exerted by the nervous system, but also by means of a chemical regulation effected through the blood or other liquids of the organism. The first serious realization of the importance of this second method of regulation came with the development of our knowledge of the internal secretions during the last decade of the nineteenth century. The somewhat meager information possessed at that time in regard to these secretions developed in the fertile imagination of Brown-Séquard to a great generalization, according to which every tissue of the body in the course of its normal metabolism furnishes material to the blood that is of importance in regulating the activities of other tissues. This idea found a general support in the facts brought to light in relation to the physiological activities of the so-called ductless glands, and subsequently in the series of remarkable discoveries which we owe to the new science of immunology. In recent years it has been restated in attractive form by Schiefferdecker in his theory of the symbiotic relationship of the tissues of the body. According to this author we may conceive that among the tissues of a single organism the principle of a struggle for existence, which is so important as regards the relations of one organism to another, is replaced for the most part by a kind of symbiosis, such that the products of metabolism in one tissue serve as a stimulus to the activities of other tissues. If a muscle is stimulated to greater growth by an excess of functional activity the substances given off to the blood during its metabolism act favorably upon the growth of other muscles which are not directly concerned in the increased work, or upon the connective tissue surrounding and permeating the muscular mass; and conversely, the development of connective tissue from any cause aids directly by its secretions or excretions in the growth of the muscle. There is thus established a *circulus benignus* by means of which each tissue profits from the functional activity of its fellow tissues. From many sides and in many ways facts have been accumulating which tend to impress the general truth that the co-activity of the organs and tissues may be controlled through chemical changes in the liquid media of the body, as well as through nerve impulses, but in physiology at least we owe the definite formulation of this point of view to Bayliss and Starling. Through their investigations upon secretin they obtained an explicit example of how one organ controls the activity of another organ by means of a specific chemical substance given off to the blood. Other facts known in physiology in regard to the internal secretions were easily brought into line with this definite instance furnished by the secretin, and Starling's convenient term of "hormone," as a general designation for such substances, has served to give a wide currency to the conception. The word and the generalization implied by it have been adopted by investigators in many fields of biological research to explain phenomena of correlation which heretofore it has been impossible to bring under the general rubric of nervous reflexes; phenomena which in fact it has been difficult to express clearly in any precise way such as might serve to stimulate direct experimental investigation. An interesting example of this application of the term and the idea contained in it is found in the theory advanced by Cunningham to explain the development and inheritance of secondary sexual characteristics. This author constructs a system of hypothetical hormones which, if present, would account not only for the development of the secondary sexual characters, as the result of the action of specific hormones furnished by the reproductive cells, but would also make conceivable a method by which these secondary characters, like other somatogenic characters, might affect the germ cells in turn in such a definite way as to be transmitted to the following generations. It is not my purpose to criticise this or similar theories. They will doubtless serve a good purpose in stimulating and directing investigations. It does, however, seem probable that the term hormone, like some of the useful terminology of immunology, will be overworked, and that investigators may deceive themselves as well as others when they conclude that any given relationship is an example of hormone regulation. It has occurred to me that it may be useful in connection with this symposium upon the internal secretions to review very briefly the state of our knowledge in regard to the hormones, with the purpose of discussing somewhat the probable nature of their action and the extent of their distribution.

In treating this subject one must consider also the more or less nearly related instances of combined activity of a chemical sort which are expressed by such terms as chemical activators, kinases and co-ferments. These terms, like that of hormone, are relatively new, they have been brought into existence by investigators to explain or to express special reactions connected with metabolism and particularly with the action of ferments. Their precise meaning must be determined by further knowledge of the facts they are intended to describe, but something may be gained by attempting to define them as they are used in physiology at present. The word activator has reference to the fact long known that the ferments, or some of them at least, are secreted in an inactive form, a proferment, which is activated or converted to an active form by a reaction with some definite substance produced elsewhere in the body. Pepsin, for example, is secreted as pepsinogen and is activated to pepsin by the hydrochloric acid formed by other gland cells. Calcium salts are necessary for the activation of the prothrombin, and enterokinase or calcium plays a similar role with reference to the trypsinogen. It is to be noted that reactions of this kind are not confined to the ferments. The typical hormone, secretin, exists in the form of an insoluble prosecretin which may be activated by acids, and, according to Delezenne, calcium takes an essential part in the activation of enterokinase, in somewhat the same way as occurs with thrombin. The nature of these activating reactions is not known. The view has been proposed that the inorganic constituents involved, the hydrochloric acid and the calcium for example, act as catalyzers which accelerate a reaction that would occur without their assistance. There is, however, no evidence to show that thrombin is formed in any amount in the absence of calcium salts, nor that pepsinogen yields pepsin without the presence of acids. As Bayliss has pointed out, these reactions belong to the irreversible group, and it is possible that the activator or one of its constituents is represented in the composition of the active substance that is formed. However that may be, it is to be noted that the process of activation is an instance of chemical co-ordination. The pepsin formed in one kind of gland cell is activated by the acid produced in a different variety of cell. The hydrochloric acid produced in the stomach is carried into the intestine with the flow of chyme and there activates the prosecretin of the intestinal epithelium either directly or indirectly. One tissue, in other words, through its products of metabolism aids another tissue in the performance of its functional duties.

The term kinase is used at present in animal physiology in connection with two reactions only. In both cases it refers to an activating process similar to those just considered, except that the activator is a colloidal substance of unknown composition. The pancreatic juice poured into the duodenum contains its proteolytic enzyme in the form of a trypsinogen which is activated immediately by trypsin by contact with the duodenal epithelium or with the secretion furnished by this epithelium. The activating substance is designated as enterokinase. It is present normally in the intestinal juice formed in this part of the alimentary canal, or it may be obtained in extracts of the mucous membrane of the duodenum or jejenum. According to Pawlow, however, the intestinal secretion obtained by direct mechanical stimulation of the epithelium is lacking in enterokinase. This latter substance is produced in fact only under the influence of some constituent of the pancreatic juice, possibly the trypsinogen itself. In other words, it would seem that the enterokinase must itself be activated before it can fulfill its functions as an activator of the trypsinogen. The chain of inter-related processes occurring at this point in the act of digestion becomes somewhat intricate, as follows: Hydrochloric acid formed in the stomach and brought into the intestine with the chyme stimulates the epithelial cells of the intestine to form secretin and to pass it into the blood. The secretin conveyed by the blood to the pancreas stimulates this organ to secrete pancreatic juice. The pancreatic juice is carried to the duodenum and stimulates the epithelial cells to form enterokinase which then activates the trypsinogen to trypsin. Assuming that all of these steps are verified by future work, we have in this series of events an excellent example of chemical co-ordination, that is to say, of co-ordination effected by chemical stimuli conveyed from one organ to another through the liquids of the body. It may be noted in passing that the epithelial cells of the duodenum under the influence of acids or soaps form an internal secretion, the secretin, while under the influence of the pancreatic juice they produce an external secretion, the enterokinase. It is of course possible that these two different functions are subserved by separate cells, but so far as our evidence goes at present we must infer rather that one and the same epithelial cell gives either an internal or an external secretion according to the nature of the chemical stimulus acting upon it. While there can be no doubt at all of the existence of enterokinase and of its wonderful effect in activating almost instantaneously the trypsinogen of the pancreatic juice, much uncertainty prevails as to its nature and its mode of action. Pawlow thought that it belongs to the group of enzymes, and this view has been supported in an almost convincing way by the experiments of Bayliss and Starling. In accordance with this view it is found that the substance exhibits a certain degree of thermolability, being destroyed at a temperature of 67 to 70 deg. C., although in this respect it is less sensitive than most of the well-known enzymes. From this standpoint the action of the enterokinase upon the trypsinogen would come under the general head of catalytic reactions, but here again it is to be observed that its action differs from that of the other enzymes in the great rapidity with which it is completed, a rapidity quite comparable to that of ordinary chemical reactions. Other observers (Dastre and Stassano, Hamburger and Hekma, Cohnheim) have contended that the enterokinase unites permanently and quantitatively with the trypsinogen, after the manner of an amboceptor and complement, to form a new and active compound, the trypsin, and the whole reaction has been still further complicated by the discovery (Delezenne) that the trypsinogen may be activated by calcium salts without the presence of enterokinase. The action of the calcium requires some time for its development, but when it occurs it takes place not gradually, but abruptly, just as in the case of the activation produced by enterokinase. The further fact stated by Delezenne that the enterokinase itself needs the presence of calcium salts before it acquires the property of affecting trypsinogen suggests naturally the thought that the action of the enterokinase may be at bottom another case of calcium activation. Pozerski states that in the inactive pancreatic juice obtained by injections of secretin calcium is not present; whereas in the active juice following upon the use of pilocarpin, calcium is contained, and the digestive action of the juice runs parallel with the content in calcium. But whether the enterokinase acts as a ferment, or an amboceptor, or a calcium carrier it constitutes a special type of organic activator, and this fact suggests the possibility that other processes in the body may be controlled by similar compounds. At present only one other organic activator of this kind has been described, namely, the thrombokinase of blood coagulation. This hypothetical substance is given great importance in the theory of coagulation proposed by Morawitz. According to this theory the blood corpuscles under abnormal environment yield an unknown substance of colloidal nature which, together with calcium, is necessary for the complete activation of thrombin, and therefore for the clotting of blood. A similar kinase is furnished by the tissues in general, so that blood escaping from a vessel and coming in contact with the surrounding tissues obtains from them a kinase which accelerates the process of clotting. The evidence for the existence of this kinase is far less satisfactory than in the case of the enterokinase, indeed one may have serious doubts

* Address of the vice-president and chairman of Section K—Physiology and Experimental Medicine, American Association for the Advancement of Science, Boston, December 28th, 1909.

whether the facts at present warrant the assumption that a specific organic kinase must co-operate with the calcium in activating the thrombin, but if the idea is demonstrated to be correct it will furnish another very interesting example of the way in which chemical co-ordination may be employed in the body. In this case the blood may be supposed to stimulate the tissue cells to form a substance not directly of importance to their own activity, but which initiates the coagulation of the blood, stops the hemorrhage and thus saves the organism from destruction. The series of events is quite parallel to that described for the pancreatic juice and the enterokinase.

In addition to the activators of the inorganic and the colloidal type there is perhaps a third kind of activation exemplified in the substances known as co-enzymes or co-ferments. This term may be used to define that kind of co-operative activity between an enzyme and some other noncolloidal substance which we see illustrated in the influence of the bile salts upon pancreatic lipase. The process differs from activation of a proferment to a ferment only in that the combination of the enzyme with its activator is dissociable instead of being permanent. By dialysis or otherwise the coenzyme can be separated from the enzyme and the action of the two may be tested separately or in combination. Perhaps this species of activation may be more common in the animal body than we have supposed. Bierry and Giaja have shown that the amylase of pancreatic juice loses its diastatic action entirely when dialyzed, and this power or property is restored upon the addition of sodium chloride. It would seem from their experiments that the amylase is active only when combined with an acid ion, such as Cl or Br, and the transition from one form to the other, from the active to the inactive or the reverse, is easily accomplished. No one can doubt that all these forms of chemical activation are allied in a general way to the more interesting and obvious mode of chemical co-ordination illustrated by the hormones. Starling defines hormones as chemical messengers which formed in one organ travel in the blood stream to other organs of the body and effect correlation between the activities of the organ of origin and the organs on which they exert their specific effect. Such substances belong to the crystalloid rather than the colloid class; they therefore are thermostable and do not act an antigens when injected into the living animal. The general idea of this definition is clear and most suggestive, but in its details it is made especially to suit the case of secretion, and therefore may not fit so well for other substances of like physiological value. Conveyance through the blood stream, while certainly the most common occurrence for this class of bodies, ought not to constitute an essential part of their definition. The secretin formed in the intestinal epithelial cell is conveyed to the pancreas in the blood and brings about a correlation between the activity of this gland and that of the duodenum, but on the other hand some substance contained in the pancreatic juice and conveyed to the duodenum in the stream of secretion excites the formation of the enterokinase, and thus correlates the activity of the duodenum with that of the pancreas. The two actions seem to be so similar, except for the means of transport, that one would naturally put them in the same class. By the same reasoning we might be justified in designating the hydrochloric acid of the gastric juice as a hormone in reference to its action in causing a formation of secretin in the epithelial cells of the duodenum. One can imagine that a similar transportation may occur in the secretions of the reproductive or respiratory passages, in the cerebro-spinal fluid, as seems to be the case for a time at least with the secretion of the pars intermedia of the pituitary gland, or even along the axial stream of a nerve fiber. If, as seems to me, the idea of correlation or co-ordination is the essential point rather than the assumption that the product must constitute an internal secretion, we might modify the definition so far as to designate as hormones those substances in solution which, conveyed from one organ to another through any of the liquid media of the body, effect a correlation between the activities of the organ of origin and the organ on which they exert their specific effect. As regards the nature of the action of the hormones on the organ affected we know too little to make any safe generalization. In the case of the secretin it seems most probable that the hormone arouses the pancreatic cells to an act of secretion, and therefore it has in this instance the value of a chemical stimulus. But in other cases the effect of the hormone may be rather of the nature of an activation. This at least would seem to be true for the hormone, of unknown nature, given off by the pancreas and concerned in the glycolysis of sugar in the organism. The effect of the hormone adrenalin upon the musculature innervated by the sympathetic system may also be of the nature of an activation rather than of a chemical stimulation.

The substances of known composition which may be regarded as playing the rôle of hormones are few in number, three or four at most, as follows: First, the carbon dioxide formed in the tissues, particularly in muscle during contraction. It seems agreed now that the carbon dioxide acts as the normal stimulus to the respiratory center. When produced in the working muscles in such quantities as to raise perceptibly the carbon dioxide tension in the alveoli of the lungs and the blood of the pulmonary veins, the respiratory center is excited to greater activity and the excess above the normal contents is thereby removed; second, the adrenalin of the adrenal glands which in some way, directly or indirectly, makes possible the full functional activity of the involuntary musculature of the body; third, the hydrochloric acid produced in the stomach which stimulates the formation of secretion in the duodenal epithelium; and fourth, possibly the iodothyrin of the thyroid gland with its dynamogenic effect upon the neuro-muscular apparatus of the body. In addition there are a number of hormones of unknown composition which have been either proved or assumed to exist, and which are held responsible for certain well-known correlations of function: The pancreatic secretin formed in the epithelium of the duodenum or jejunum which stimulates the flow of pancreatic secretion; the gastric secretin formed in the pyloric mucous membrane which gives rise to the chemical secretion of gastric juice; a secretin formed in the duodenal epithelium which stimulates the formation of intestinal juice in the following segments of the intestine; unknown hormones of pancreatic origin which determine the absorption activity of the intestinal epithelium; vaso-dilator hormones formed in tissues in functional activity and which have a specific effect upon the vessels of the functioning organ; a vaso-constricting and a diuretic hormone formed in the posterior lobe of the pituitary body; a hormone controlling the growth of the bones and connective tissues produced in the anterior lobe of the pituitary body; a hormone controlling the oxidation of sugar in the body and produced in the cells of the islands of Langerhans in the pancreas; a hormone produced in the thymus which controls possibly in some way the development of the reproductive organs; a vaso-constricting hormone formed in the kidneys; a hormone in the salivary glands which controls the flow of water from the blood capillaries in the glands; a hormone produced in the fœtus in utero which stimulates the growth of the mammary glands; a hormone in the ovary which controls the growth of the uterus and the processes of menstruation; a hormone in the ovary which controls the implantation of the fertilized ovum and the growth of placental tissue; a hormone in the testis which initiates the development of the secondary sexual characteristics in the male; hormones of an indefinite number, produced in all the tissues and acting specifically upon the determinants in the gametes in such a way as to make possible the transmission of acquired characteristics. It is evident from this summary that there is a well-developed tendency in physiology at the present day to utilize the conception of hormones to explain all relationships not otherwise intelligible. A few years ago the number of hypothetical enzymes in the body was likely to be increased whenever a new research in metabolism appeared, now the drift seems to be in the direction of manufacturing new hormones. This natural inclination to abuse a new and attractive idea will not of course prejudice us against the great importance of the suggestion which we owe to Bayliss and Starling. It is to be hoped only that no one will be tempted to give to these hypothetical hormones distinctive names, except in cases such as the secretin, adrenalin, etc., in which the substances have been isolated in some degree of purity. For once a specific name has become attached to an entirely unknown substance, it acquires henceforth an easy currency in our literature, and soon many of us unconsciously assume that the thing so designated constitutes one of the verified facts of our science. By way of example one may cite the thrombokinase which has become such a familiar term in the literature of coagulation and which not infrequently is employed by writers as though its existence were a settled fact.

Among his other valuable suggestions regarding the characteristics of the hormones, Starling has called attention to the fact that some of them act by increasing the processes of disassimilation or catabolism, while others apparently stimulate the processes of assimilation or growth. In this latter group we may include the hormones of the anterior lobe of the pituitary body, according to the present conception of the functions of that gland, and all of the hormones of the reproductive cells. These latter have in general what has been designated as a dynamogenic action, they cause hypertrophies in various organs or tissues and invoke therefore processes of synthesis rather than those of splitting and oxidation. Hypertrophy as an outcome of increased functional activity is a familiar phenomenon, but as Nussbaum remarks, the hypertrophy induced by testicular or ovarian hormones resembles rather the effect of the growth energy exhibited by the developing embryo, in that it is dependent upon influences other than those arising from functional use. What these influences may be is at present a matter of pure speculation. In his recent most interesting contributions to our knowledge of growth Rubner has been led to assume that the property of growth in the young organism is connected with certain special chemical complexes in the protoplasmic material, complexes which have nothing directly to do with the simple maintenance of the nutrition of the cell and which after adult life is reached disappear for the most part from the general soma. In line with this hypothesis one might assume that the hormones given to the blood by the reproductive cells contain such complexes which when anchored in certain tissues lead to an accelerated growth. Perhaps the clearest and most interesting experiments made upon the reproductive hormones are those reported by Nussbaum. He chose for his experiments the males of *Rana fusca* whose reproductive organs go through a cyclical period each year. At the proper period the preparation for the mating season shows itself in the hypertrophy of the seminal vesicles, of the thumb pads, and of certain muscles in the forearm. If the frog is castrated these hypertrophies do not occur, or if they have begun before the castration is performed retrogressive changes take place. On the other hand, the usual hypertrophy of the nuptial organs can be initiated in a castrated frog if pieces of the testis from another frog are introduced into the dorsal lymph sacs. The pieces thus introduced do not become grafted permanently, but are gradually absorbed and the growth of the thumb pads and of the muscles in the forearms falls off after this absorption is completed. Nussbaum believes that the stimulating effect of the testicular hormones is not exerted directly upon the tissues which show the increased growth, but rather upon the portions of the central nervous system which innervate these tissues. This belief rests upon the experimental fact that if the peripheral nerves going to the glands and papillæ of the thumb pads are severed on one side the testicular hormone affects only the other intact side. This experiment and the conclusion drawn from it opens up the interesting question whether perhaps the reproductive hormones in general exert their effect through the central nervous system. This has not been the usual belief, and the experiments of Nussbaum are open to the obvious objection that the section of the peripheral nerves may have induced certain secondary changes in metabolism which indirectly antagonized the action of the testicular hormone. At present these experiments, so far as I know, have not been repeated with this objection in mind, and it is somewhat gratuitous to criticise the author's conclusions until further work is reported.

RUBBER AND FIBER COMBINATION.

ACCORDING to Consul-General John L. Griffiths a member of a tire company in London has been conducting experiments to produce a rubber compound, combining pure rubber with a vegetable substance, that will avoid the defects which he thinks are produced by the common method of incorporating mineral substances, such as magnesia, chalk, and oxide of zinc. The experiments have developed a process by which the vegetable fiber employed is made to pass through the rubber in all directions in minute threads. In this way the rubber and the fiber are caused to act in support of each other, with the result that the compound is remarkably tough and retractile, and resistant under pressure or tensile strain.

A new method of producing nitrogen from the air by combustion has been patented by E. F. Aumont. The invention relates to the separation of nitrogen from atmospheric air by the complete combustion of a combustible gas, and the subsequent removal of carbon dioxide and water vapor from the product. A suitable apparatus for the purpose comprises a mixing chamber for the gases, a combustion grate (cooled, if preferred), with narrow openings to prevent the flame striking back into the mixing chamber, and a closed combustion chamber, with a suitable arrangement for cooling the burnt gases. The combustion may be controlled by the use of an apparatus for automatically determining and recording the proportion of carbon dioxide in the burnt gas, and, where the composition of the combustible gas is variable, an automatic regulator may be introduced; this consists of a metal tube filled with copper, maintained at about 400 deg. C., through which a part of the burnt gas is made to pass; the tube is connected with one pole of a source of electricity, and the copper is connected at various points through the coils of four electro-magnets, with the other pole; any excess of oxygen reduces the conductivity of the copper by oxidation and causes one or more of the electro-magnets, which control the air supply, to become inactive. A water blast (filter-pump) is preferably employed for withdrawing the gases from the combustion chamber; this cools the gases and effects the absorption of carbon dioxide therefrom, leaving nitrogen to pass on to the receiver.

MEASURING INSTRUMENTS OF LONG AGO.—III.*

THE MECHANICAL APPLICATION OF GEOMETRICAL PRINCIPLES.

BY WILLIAM E. STARK.

Concluded from Supplement No. 1796, Page 366.

MAP-MAKING INSTRUMENTS.

SEVERAL ingenious instruments were devised especially for taking observations over a considerable area and recording the data in the form of maps. In most, if not in all cases the map was made "in the field" as in the case of the modern plane table. If two points

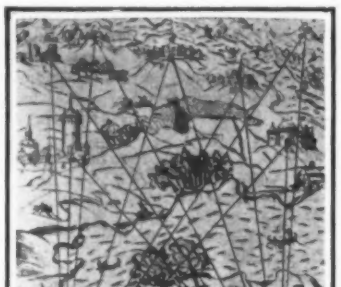


FIG. XXX.—LOCATING OBJECTS BY OBSERVATION FROM A SINGLE BASE LINE.
From Danfrie. See note under Fig. VIII.

on a sheet of paper are taken to represent two points on the ground, the position of a third point may be obtained by transferring to the paper the lines of direction to the third point from the two points of observation with reference to the line between them. (Fig. XXX.) Thus from two stations the relative positions of all points visible from both may be obtained, provided the direction lines do not intersect too obliquely. If the distance between the points of observation is known, any other distance may be taken from the map by scaling.

In some instruments, the directions were obtained with reference to the meridian by use of a magnetic needle. Fig. XXXI shows a compass described by Bartoli, 1589. The vertical circle and alidade enabled the observer to take observations conveniently to points at a different level than his own, and when desired to determine the difference of elevation. The student should note the error involved when the pivot of the vertical alidade is not exactly horizontal.

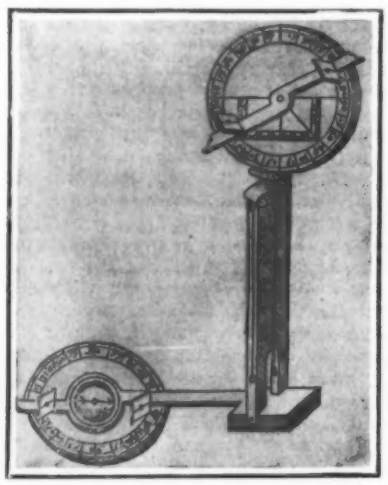


FIG. XXXI.—MAGNETIC COMPASS WITH HORIZONTAL AND VERTICAL SIGHTS.
From Bartoli. See note under Fig. XXII.

The *trigometre*, invented by Philippe Danfrie and described by the inventor in a beautiful little book† published in Paris in 1597, enabled one to read directly from the instrument the distance from either end of the base-line to a third point. (Fig. XXXII.) A rectangular bar, called the base, carried at one end a pivoted rule with sights and a graduated semicircle for measuring the angle between base and rule. A second rule was attached to a clamp by means of which its pivoted end could be set at any point on the edge of the base. This rule also carried sights and graduated semicircle and both rules and base were marked with similar scales of equal parts.

The sight at each pivot could be turned so as to permit sighting either along the base or along one of the rules. Both rules could be clamped in any position on their semicircles. The whole was mounted on a tripod with adjustable joint for orienting and leveling, and carried a magnetic compass.

In practice, the instrument was set up at the right end of a base-line, and with the base horizontal and parallel to the base-line. The right rule was then aimed successively at the various points to be mapped and the angles recorded. The instrument was next moved to the other end of the base-line and the base set in position by sighting back toward the first station. The left rule was now clamped in such a position that the reading on the scale of the base corresponded to the length of the base-line. With the right rule clamped at the angle previously recorded in connection with a given object, the left rule was aimed at the same object. The readings of the rules at their intersection then gave the distances of the object from the ends of the base-line. For measuring differences of elevation, the instrument was set in a vertical plane by means of the adjustable point. A pendulum attached to the right rule was used for setting this vertically.

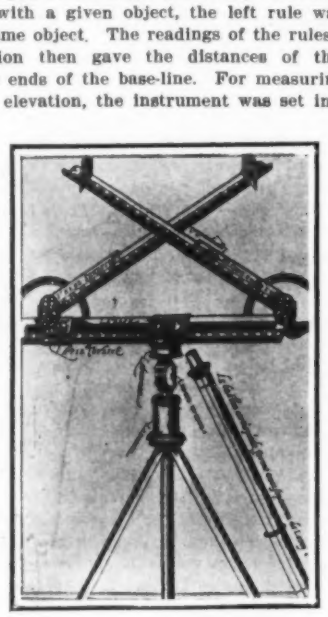


FIG. XXXII.—DANFRIE'S TRIGOMETER.

Valletto,* in a little book published in Venice in 1564, describes an instrument on the same principle as the trigometer which he calls a "holometro."

LEVELING INSTRUMENTS.

Inventors of leveling instruments made use of the free surface of a liquid, of the plumb-line, and in the later instruments, of the bubble-tube. Figs. A, C, and G in Plate XXXIII, taken from Bion, illustrate the three types. Apparently all three were in use when Bion wrote.

There were numerous devices for determining a line perpendicular to a plumb-line. In a very old† form (Fig. XXXIV), a frame like the letter A carries a plumb-line attached to the vertex. When the line hangs over the mid-point of the cross-bar, the feet of the A are in a horizontal line. The verification of this relation is a good problem for the beginner. In some forms of the instrument marks were placed on the cross-bar corresponding to the angle of slope of the line formed by the feet of the A.

Many of the devices already described could be used for projecting a level line, for example the geometric square, the quadrant, and the octant. In all of these, the sights could be set at right angles to the plumb-line which was an essential feature of the instrument. (Fig. XXXV.) Some examples of levels of the plumb-line type were designed to give the greatest possible accuracy. The instrument (Fig. XXXVI) described by Bullet,* architect to Louis XIV. was in the form of a letter H. One of the uprights was hollow and a plumb-line several feet long which was hung inside

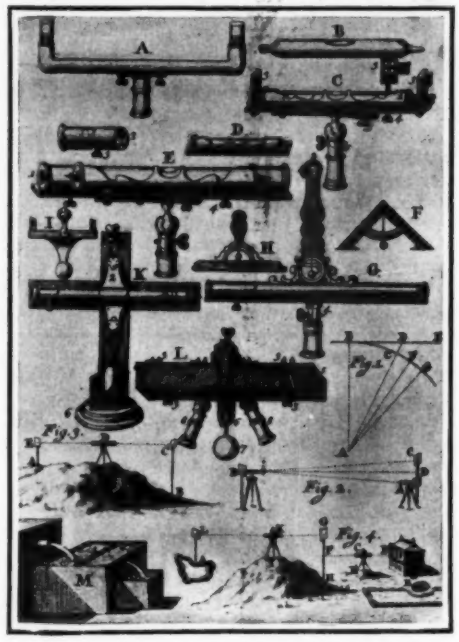


FIG. XXXIII.—LEVELING INSTRUMENTS.
From Bion.

it was visible through a glass panel. The plumb-line was thus protected from the disturbing action of the wind. The horizontal member of the frame was at least six feet long and carried sights which determined a line perpendicular to the reference line ruled at the back of the plumb-line case. A rack on the second upright and a pinion with the crank pivoted at one end of the horizontal member enabled the operator to raise or lower this end until the reference line referred to above, lay under the plumb-line. An alidade was also attached to the instrument for measuring, by means of a scale marked on one of the uprights, considerable elevations, as with the geometric square. A quadrant was also attached for measuring vertical angles which, with the aid of a table of sines, could be used in place of the vertical scale for determining heights. Fig. XXXVII shows the instrument in use.

Bion shows (Fig. XXXIII, *I*, *K*, *L*) a self-adjusting level of the plumb-line type, a sight being hung from a single support by means of a piece of metal carrying a heavy weight. The whole apparatus was so

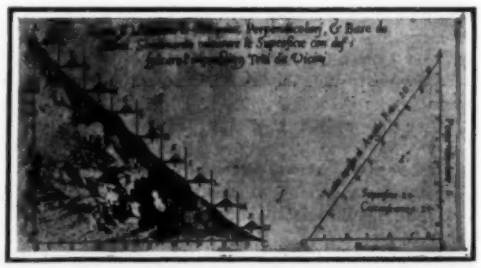


FIG. XXXIV.—LEVELING WITH A PLUMB-LEVEL.
From Pomodoro, See note under Fig. III.

adjusted that the line of sight was perpendicular to a line through the point of support and the center of gravity of the instrument.

Special instruments of various forms were invented for the use of artillerists in setting cannon at any desired angle of elevation. (Fig. XXXVIII.) Such instruments were often combined with scales giving the weight of iron cannon balls corresponding to various diameters or calibers of pieces. In this connection a pair of caliber compasses or calipers is shown (Fig. XXXVIII, *A*) as an application of the properties of

* School Science and Mathematics.

† Declaration de l'Usage du Graphometre. Philippe Danfrie. Paris, 1597.

* Discrittione et Uso dell' Holmetro. By Abel Fullone Valletto. Venice, 1564.

† E. N. Legnazzi. Del Catasto Romano e di Alcuni Strumenti Antichi di Geodesia. Drucker, Verona, 1887. Plate XVII.

* Traite du Nivellement. Par le sieur Bullet. Architecte du Roy. Paris, 1688.

similar triangles, although it has no device for measuring inclination. The jaws of the calipers end in a double set of points, the inner pair for use in measuring the diameter of the ball, the outer pair, the caliber of the gun. The student may show that there will be a constant ratio between these two measurements for all settings of the instrument. A metallic finger hinged at about the middle of one arm indicates on a scale on the other the weight of bullet corresponding to the opening of the points.

As stated at the beginning of this article, my purpose in describing these old instruments is to suggest applications of mathematical principles which will add

FIG. XXXV.—LEVELING WITH QUADRANT.
From De Judaeis. See note under Fig. VII.

to the interest and significance of the formal work of our high school courses. I have mentioned only a few class exercises which may be based on this material, but I hope that teachers who have felt the need of more concrete illustrations will find many opportunities of using these examples of the applied mathematics of a bygone day.

THE RODIYAS: A RACE OF OUTCASTS.

THERE is in Ceylon a community of people who are, like the Indian pariahs, absolute outcasts from all society. They gain their livelihood, if they labor at all, by the most degraded of work, making ropes from the hides of cattle, an occupation abhorred from its ancient association with the hangman. They also prepare the skins of monkeys for use in making the native drum or tom-tom. They are paid for these in kind. They deposit their handiwork outside the houses of likely purchasers. If the ropes and skins are needed, they are taken in and boiled rice is left in their place. Naturally, this people, living for centuries under a system so insulting, is in every way shameless and brutalized. Most of them live as itinerant beggars. The men are often well made and not ill-favored; sometimes tall, and of a pleasant, light brown complexion. The women are many of them among the finest specimens of womankind in the East. They wander about the countryside, giving displays of dancing and juggling. Their moral code is very low.

Of late years, under the British government, this unhappy tribe has made some advance in material things, though the social stigma remains. As regards education, their condition is deplorable. They could not be tolerated in schools along with other children;

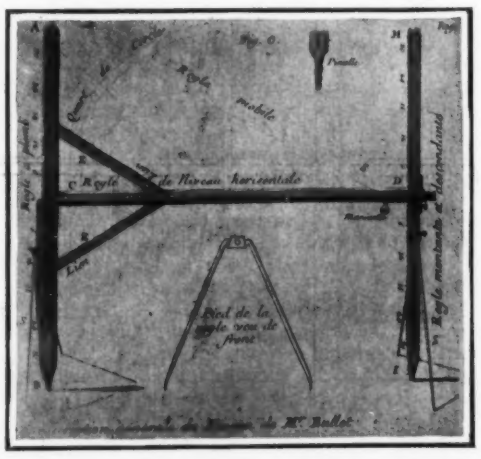


FIG. XXXVI.—INSTRUMENT FOR LEVELING.
From Traite du Nivellement by Bullet, Paris, 1688.

their presence would be an abomination. Nor have they had any schools of their own until recent years, when a mission has started work among them. Under these circumstances they have had no chance of improvement; they have sunk lower generation after generation. But now it is the intention of the government to make a determined effort to raise them. Their children are to be educated in properly organized schools established in their villages. They are to be given opportunities of becoming landed proprietors, and efforts are to be made to teach them agriculture. They are to be taught trades, too, and markets are to be found for what they produce.

The origin of the Rodiyas is lost in obscurity. Popular tradition among the Sinhalese states that they are the descendants of royal huntsmen who were banished and degraded for an abominable crime; they served up human flesh before the king on a day when they had been unsuccessful in the chase. There is no reason to think that this story is anything more than a myth, having its source in a natural tendency to assume a terrible cause for so terrible an effect. Brahminical influences must not be lost sight of. Among Orientals, in whose philosophy life was all misery and death a happy escape, the extreme form of punishment would not be death, but a continuance of life under conditions which should add to its misery by every conceivable means. So the Rodiyas would be the descendants of people condemned for various crimes to this form of punishment; and their ranks would be added to from time to time. There are, moreover, authentic records of cases where offenders guilty of high treason and similar crimes were cast out by the kings of Kandy to join the Rodiyas, their wives and families being cast out with them. This would explain the fine physique of this people and the good looks of their women, for some of the best blood of Ceylon must flow in their veins, recruited as they have been from the ranks of treasonable nobles and fair but frail princesses. It has been thought, on the other hand, that the Rodiyas are the representatives of some foreign race, oppressed and degraded by their conquerors. There is, in fact, a reference in the Mahawanso, the Sinhalese history of Ceylon, to a village of outcasts in Ceylon in the fifth century, A.D., of Hindu origin, and it is supposed that these people had immigrated from the coast of India, and were of Chandala blood, a tribe so degraded that their shadow was pollution. So far, however, as physical tests are concerned, there seems little to distinguish the Rodiyas from the rest of the Sinhalese, while their language only differs in a few words peculiar to it which approximate mainly to the Gipsy tongue, and it is easy to understand how an outcast people woud pick up many words from a wandering tribe like the Gipsies.

In considering the origin of the Rodiyas, one cannot but be struck by the strange resemblance between their position in Ceylon and that of the Cagots and Caqueux in the Pyrenees and in the plains of Bretagne, Poitou, and Guienne. There is hardly a point in which they differ. The Cagots and Caqueux dared not draw water from a public well, or touch the parapet of a bridge with the bare hand; their persons were contaminating; they had to wear shoes to protect the earth from pollution, and they bore a red mark on the shoulder to warn travelers of their identity. Though allowed to become Christians, they had a separate entrance to the church, a separate bowl of holy water, and a separate burial ground. Their descent is equally uncertain; it is thought by some that they were sprung from Gothic or Moorish oppressors overcome and expelled from the pale of society for their past enormities; by others, that they were representatives of alien religions, Arians, Jews, or Mohammedans, and loathed and abhorred on that account from times when religious toleration was inconceivable. There is no proof in either direction; but there is one striking similarity between them and the Rodiyas which suggests a like origin for both Western and Eastern pariah. As I have said, we find the Rodiyas engaged in making ropes from hides of cattle, an occupation held in particular abhorrence from its association with the hangman. In the same way the Gagots were carpenters and the Caqueux were ropemakers, and both trades were alike infamous at an early period because the carpenter furnished the gibbet and the ropemaker the halter for the executioner. This fact supports the idea that the origin of the loathing in which these people were all held may be found in this association between them and the hangman. Now it is a fact that in the times of the Sinhalese kings executioners were always drawn from one class—namely, that degraded section of the community known as Candalas. This class may be connected with the Candalas of India mentioned in the Mahawanso; that it was a most degraded society is certain. There was, at a late date, some confusion between the two classes, the Candalas and the Rodiyas, and the term Candala is sometimes used in the sense of Rodiya. The Rodiyas, however, occupied a position inferior to the Candalas, and seem to have been attached to them as servants. One indication of that is to be found in the fact that, while the Candalas are extinct by absorption into the surrounding peoples, the Rodiyas still exist as a distinct tribe, too low to have any hope of absorption. The Rodiyas would naturally, in their capacity as servants, be the makers of the ropes which the Candala executioner used for his opprobrious trade, and would be the objects of an even greater contempt than that with which their masters were regarded. Some such origin as this for the degradation of the Rodiyas seems most probable—it accounts not only for the intensity, but for the persistence of the loathing with which the tribe was regarded.—G. F. Plant (Ceylon Civil Service) in the Manchester Guardian.

A NOVEL RADIOMETER.

A SIMPLE and novel radiometer has been devised by Mr. R. H. Smith, an English inventor, for measuring the amount of radiation falling upon, and absorbed by a black rough dull surface. The radiant energy absorbed takes the form of heat which is immediately conducted to water flowing slowly through a small tube, and the rise of temperature of which is meas-

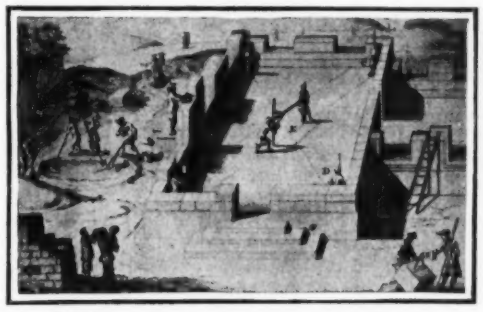


FIG. XXXVII.—USE OF BULLET'S LEVEL.
See Fig. XXXVI.

ured. The principles on which the apparatus is designed are first, the use of a very large absorbing surface—one square foot. Second, the proportionment of the water flow to the rise of temperature so that the percentage of error in each of the two measurements is about the same; and third, the raising of the temperature of the receptive surface so slightly that its loss of heat by radiation in unappreciably small. Under different conditions of the use to which the instrument has so far been applied, namely, the testing of open fires and other house heating arrangements, the proper flow of water varies from 0.375 to 0.75 pound per minute, and the rise of temperature from 6 to 10 deg. F. The thermometers are graduated to one-tenth deg. C. or one-fifth deg. F. Practically the whole of the heat received is collected in the water and 0.5 per cent accuracy in its measurement is easily attainable.

The surface is composed of a coil of small extremely thin copper tubes measuring over 50 feet in length, through the extent of which water flows by gravity under a head which is kept constant during each test, but which can be varied according to the intensity of the radiation to be tested. The square tube forms a complete unbroken flat surface. The water flow is accurately measured by weighing the water collected

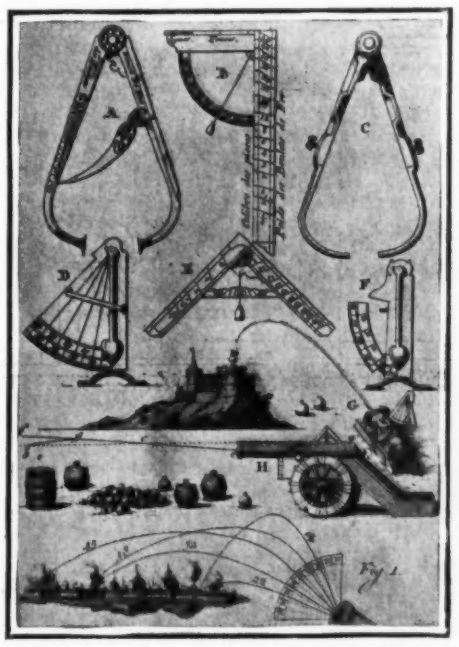


FIG. XXXVIII.—ARTILLERIST'S INSTRUMENT.
From Bion.

every five minutes. It can be measured more quickly and easily volumetrically in an eudiometer.

The receptive surface of copper tube is carefully shielded from any cooling by convective air currents by a protruding open box in front and by a closed hollow non-conducting box behind. The sides of the front shield are of thin good-conducting metal, and are blackened both internally and externally. Nevertheless, it is advisable to place the instrument at not less than 6 feet from the source of radiation in order

to secure an approximately parallel radiation falling upon it.

The sensitiveness of the instrument has been illustrated by placing a two-inch cube of fresh black coal upon a large open bright fire in a grate measuring 24 by 13 inches with 7 to 8 inches depth of fuel, and the indicated radiation has changed sensibly in one minute.

There is considerable viscous and frictional resistance to the passage of the water, even at the slow rates of flow used, through the long length of small tube, and the work done in overcoming this resistance eventually appears as heat in the water. But this amount of heat is not more than about one-hundredth of one per cent of the whole heat measured. This consideration points to keeping the water flow as low as possible consistent with avoiding a too high rise of temperature.

TAILS AND THEIR USES.*

WHY NATURE CREATED CAUDAL APPENDAGES.

BY JAMES NEWTON BASKETT.

WE are very apt to regard the tail as merely "the other end of the body," but nature seems to have early esteemed the member and made it her most efficient implement of locomotion. The fish forms are propelled almost wholly by it, and as a distinct part of the backboned body it is really older than the head, and was the first part of the spine to be vertebrated, if we are to heed the suggestions of embryology and paleontology.

Below the vertebrates it had become a great tool, for the crustaceans, of which the lobster and the crawfish are types, shot backward by means of this wonderful propeller, and here it took on early the form of a hand or clasper, since the mother articulate, when she walked out on dry land at least, in passing from swamp to swamp, carried then, as now, doubtless, her eggs or young under the grasp of this terminal flipper. Among the insects closely related the tail is interesting as a support for various implements, useful in their economy, such as stings, ovipositors and pincers. The first two are common and the last may be seen on the end of the male dragon fly, whereby he clasps the slender neck of his mate and steadies her while she, with much effort, thrusts her ovipositor into a tough reed stem. This is a case where there are two remarkable terminal implements in the family. Perhaps no more delicate contrivance is found in nature than the cluster of spinnerets found on the caudal extremity of the spiders.

THE FISHES' TAIL.

Among the vertebrates the tail reached its perfection as an essential in the fishes, where, as noted, it is almost solely the means of motion, for the fins are largely balancing members. The terminal fringe is, without doubt, the parent of the upper and lower unpaired fins, and it is not improbable that the paired fins came out of it also. If this be true, the legs of the quadruped had their origin here and the human hand may have been cradled with the caudal fin among the rushes.

The shape and other characteristics of the tail-fin may tell much of a fish's ancestry and modern habits, but further discussion of this is precluded here, more than to say that those swimmers with tails widely forked are apt to be more speedy and game than those with square or rounded tails, as any one may recall who has had the mud cat and the channel cat on his line. The higher fishes have the tail stuck straight into the fringe, but those of the shark tribe have it turned up within the fin, like a sled runner; and usually their upper lobe or fork is the longer. This is so exaggerated in one shark called the thresher that while lying on the surface it can thresh or strike the whale well up on his great sides; and an attack of a few of such lambasters is said to prove fatal to the leviathan at times. The tails of fishes usually give beauty and symmetry to the body, but they are much modified, and the great sunfish of the sea has no tail proper, but is merely fringed on the blunt rear end of the body. Among the skates and rays the tail is round and quite unfishlike, and the sting-ray has two spines on it, secreting an acid fluid around them. By these there may be inflicted a painful wound.

THE TAIL SALUTATION.

Among the peculiar tailed fishes the sea horses are alone in having the tail prehensile. With it they anchor themselves to seaweed and other things in strong currents, for they are poor swimmers. Here, too, is the first manifestation of the emotions by means of the vertebrate tail, for as two of these interesting creatures meet they may clasp tails for a moment and then pass on, as if they had wished each other well. They have thus antedated our handshake a few cycles.

The water-haunting members of the amphibians, to which the "mud-puppies," salamanders, efts and frogs belong, retain the tail, somewhat flattened, as a swimming member, while with those which are more land-haunting it is round. As is well known, the frogs, when grown, dispense with it as a hindrance in leaping, and it is the first creature in the vertebrate scale to lose every external vestige of this member and to dispense wholly with its uses. The absorption of the tail in frogs and toads is the most interesting biological process known to take place after the creature has left the egg, and the loss, even before hatching, in some forms, adds a factor of study of more interest than those exhibited by the usual tadpole. Some frogs are hatched tailless—the tail being fully formed in the egg, but absorbed before coming forth.

QUEER USE OF THE TAIL.

We have seen that up to this time the tail had few uses beyond that of action and some modification as a weapon. The reptiles cultivated all this more extensively, and introduced some novel practices with this member. In the first place, besides paddling, or sculling, with it in the usual way when they went into the water, they used it as a rudder in flying, and later made it help spread a membrane for gliding on the air. On one of these old skin flyers the tail was a long affair with a stem and a racket-shaped expansion at the tip, which steadied his aerial gait in a manner not unlike the rudder of the modern aeroplane. But among the reptiles only is the tail used as a prepaid ransom, or a sacrificial offering. Many of the lizards have the organ so feebly "connected up" as to break off easily, if it be pulled at as the creature tries to escape, and the owner is thus able to go maimed into safety rather than remain whole in the stomach of the enemy. Thus, our little so-called glass snake, which is not a snake at all, but a legless lizard, found in Missouri and southward, has such a tail in great perfection. Between the joints of the vertebræ run gristly septums or disks, and these extend through the skin. They adhere so slightly to the tissues which they touch that the exertions of the lizard itself, in a sudden attempt at escape, may break the tail, and a slight blow with a switch at the joints causes fracture. The wriggling remnant is such an attractive tidbit to the pursuer that he may allow the body to go. Indeed, the owner itself has been known to turn and swallow its own extremity, perhaps without knowing what it is. For these reasons this lizard is in some regions called the "jointed snake." The parts never reassemble, as is popularly claimed, but the creature can grow a new tail. It is not, however, so well shaped as the old one. In this connection it may be said that the ready manner in which the skin slips on the tails of many of the rodents seems to imply some similar purpose, and the tail features of birds are always loosely set for the same reason. The squirrel very consciously puts his tail between his body and an expected danger, explores scary places with it stuck out well in front of him, and curls it over his back when he eats, as much as a shield as an ornament. In all these cases his hope is that if the enemy make a dash the tail may be grasped and the body missed, his worst foe being usually the hawk above him.

AS A MEANS OF SUPPORT.

Besides its aid in flying, the reptiles first used the tail as a balancing member and as a fifth leg when sitting up bipedally. The old fossil monsters so braced themselves while resting, and such as walked like birds, and made those celebrated birdlike tracks in the Connecticut Valley, may have used it as a balancing pole, as they strode. One little modern lizard, called the frilled lizard, so uses it now, when he gets good and angry and struts away with only his toes touching the floor, while the tail is stuck out far behind as a stiff poise. Of course, many quadrupeds higher up the scale sit erect by the use of the tail as a prop, notably the kangaroo. Excepting the case of the seahorse, noted, the reptiles first used the tail prehensilely. The tree lizards, many of the snakes, and the true chameleon (not the little aneolis of the South, so called) grasp well with the tail. One snake has the honor of having the only tail in nature specifically shaped and armed for burrowing. On the "shield tail" the body ends squarely and there is a horny, flat shield across the frustum by which the creature pushes itself into soft earth. The tails of some other snakes, however, have horny tips to aid in burrowing, among which is our common pine snake.

AS A MUSICAL INSTRUMENT.

The snakes have the honor of first making the tail a musical instrument, for more than one of these horny tips may vibrate in anger against dead leaves, or grass, to make a whirring sound of bluff or threat. It has been thought by some students that this is done in conscious imitation of the peculiar sound of the rattlesnake, but it is more likely that the latter's melody is only a greater development of musical talent on a much superior instrument. At least this is the apparent history of the development of most other peculiar endowments. By some lucky means he was not able to complete his moult, and portions of his old skin remained after each shedding till he found a toy which became useful as a means of safety, and persisted because of such purpose. Just what use a turtle has for a tail we cannot see, but it seems to remain as a vestige of a time when it was useful. That of the "snapper" has blunt spines or buttons on top of it, hinting a time when his ancestors used it as a weapon just as the back buttons on our dress coats hint the time when our ancestors wore swords. Some of the most formidable creatures ever known, especially for defense, were the old fossil reptiles, on the terribly muscled tails of which, scores of feet long, were fearful three-pointed spines. The alligator faintly keeps up the reputation of the family in this respect, and the monitor lizards strike a stinging lash with their whiplike tails.

TAILS OF BIRDS.

The actual tails of birds now are just a little bunch of tissue, strongly and intricately muscled, into which feathers may grow; and it is by these latter that we estimate their caudal extremity. But the early fossil birds had good, long, bony tails, out of the slight tissues of which the feathers scantly stuck on each side in a horizontal plane only. Such tails, minus the feathers, the birds inherited from their ancestors, the reptiles, but now they are all jammed up short and carry feathers which are largely ornamental. The story of the tails of birds is almost a treatise, for nature has run riot here in form, structure, color, and extent of feathers. The tail of the peacock is only a long tuft of feathers growing from the back and is supported by the brief true tail beneath.

The bird's tail is not so useful in flight as is usually supposed, and while one suddenly deprived of it may fly awkwardly at first he soon adjusts himself to the new conditions. It is only slightly used as a sidewise rudder, notwithstanding the frequent assertion of even fairly good observers, and is not essential to guiding or rapid turning. Some of the birds and flyers that take insects most expertly in the air have short tails, such as bats and swifts and hawks, and those with long tails are by no means among the great pursuers. In alighting, in stopping suddenly, in any up-and-down motion and in balancing while sailing the bird's tail has its greatest use, and it began its career evidently as a kitelike surface in rising and sailing down, while the legs of the first bird known were made broad by similar horizontal feathers for the same evident purpose. In a few birds, now, such as woodpecks, swifts, etc., the tail is used as a prop.

Among the group of quadruped animals known as mammals the tail has reached its most interesting and varied uses. It may be a weapon, a bed, a coverlet, a respirator, a finger or hand, a probe, a shield, an umbrella and a whole vocabulary of emotions. The long-tailed monkeys balance by it, and one is said to sleep hanging by it; mother monkeys and opossums support their young with it, as these sport on the maternal back; the kinkajou (a coon form) coils it like a rope beneath him and lies upon it; the foxes, coons, lemurs and others cover the thinly clad parts with it during rest and thrust the nose into it as a respirator during sleep; the great anteater walks abroad more comfortably in the hot South American sun under the shadow of it; the "beasts of the field" fight flies successfully with its fierce lash, and the leviathans of the water propel themselves forcibly by it, as may be seen in the whale tribe, the seacow forms, and to a certain extent among the seals. In some of these last and cer-

* St. Louis Daily Globe Democrat.

tain bats it is used to spread a membrane upon, by which it is tied to the rear legs, and in these it again becomes a factor of flight.

A MEANS OF DEFENSE.

Among the uses of the tail as a means of defense, that of the American porcupine is unique. Here is the only place where there is a detachable secondary weapon on this member, for its quills come loose readily, and the creature makes a conscious threat and stroke, for the purpose of driving them into the enemy. In fact, there is a creditable record of these quills flying off from a flip of the tail and striking a piece of hardwood with a force sufficient to remain sticking into it like an arrow. If this habit were usual or more than accidental, this would be the first use in the scale of beings where a mechanical projectile was used—at least by the tail. One of the fishes brings down flies by shooting a jet of water, and the conventional monkey hurls cocoanuts, of course.

The porcupine waves its tail threateningly when disturbed, knowing the power of this armament. It is said by foresters that if the tail of one be chopped off as he sits lengthwise of a limb he will remain in this spot indefinitely, seeming not to know how to proceed without this important adjunct. Nowhere is the tail used more as a threatening or bluffing member than among mammals, as may be seen in the cat tribe and many others. By it all felines seem to express a sort of diabolic delight as they are creeping upon their prey, and all tend to lash their sides with it in rage. Here also the tail is used extensively as a larder or a place to store fat in, for consumption in winter stress or summer droughts. In lemurs there are reservoirs of fat at the root of the tail, and a certain sheep among the Hottentots is well known to have a fat tail of such value that the owners make the animals a little wagon to haul the precious part around with, that it may not be bruised on the rocks. This is the greatest use that the beaver has for his extensive, thick caudal member—to live off in winter. It is by no means his trowel, as some of us were taught in our readers, but it is useful in sudden diving, though not necessary. An incidental use of it is in warning his fellows of approaching danger by making a resounding slap with it on the water as he goes under.

"THE WHITE FEATHER."

Dr. A. R. Wallace, in his remarkable theory of signal or banner colors, has shown that a sort of unconscious altruism may be marked upon the tails of birds and mammals, which makes each of those that are social something of his brother's keeper—at least mechanically. It is certainly a noticeable fact to any student that many flocking, or fleeing gregarious creatures, are apt to display certain conspicuous spots, on their rear parts, such as bands or blotches, when they attempt to escape. Some of these may be in plain sight all the time, and others will be hidden when the creature is at rest. In some, as the birds, the act of flight will display such as wing bars, white rump spots, or white feathers in the tail, which are wholly covered up when perching. Our common little snowbird (junco) furnishes a striking example, and even the white wing bar of the house sparrow is such a mark.

On the snowbird the white feather is on the outer margin, and wholly hidden when at rest, for the evident purpose of not making the bird conspicuous then; but when those of the flock that are first alarmed, or are the strongest, take flight, this white signal furnishes a guide to those that should follow. This display in fright and flight is where we get our phrase of "showing the white feather."

In like manner, the tails of many mammals are white below and not above. Thus the deer and the hare hoist a white flag when they run, and not when at rest. Some hares do not have this arrangement, and show that they are further away from their ancestors among the social habits. Deer and antelope may have this form of tail, because they make for safety more by flight than do the cow kind; and for this reason their tails are shortened. There is much that is plausible in this theory of Wallace, and it makes every tail interesting, as, like a blessing, it takes its flight. Tails, as well as tales, may tell much of history, and they have in them more than is usually dreamt of in our philosophy. A proper elucidation of all pertaining to their discussion would make a treatise.

THE PLANET MERCURY.

RECENT OBSERVATIONS.

BY W. F. DENNING, F.R.A.S.

MERCURY, the smallest of the primary planets and the most difficult to observe satisfactorily, seems to have been neglected by the majority of telescopic students. They regard it as an object not only seldom visible, but one which holds out a poor prospect for successful research. But this planet may deservedly claim more attention, for several important features require settlement. There are certainly markings of fairly definite outline presented on the disk. They are, however, very seldom seen to advantage, owing to the small and fluttering image. At the time of examination the planet is usually not far from the horizon, and the disk only seven seconds of arc in diameter. A pretty high power must be used. I found anything below 200 ineffective; 312 and 350 the best.

It is, perhaps, surprising that more earnest efforts are not made to overcome the hindrances to obtaining a far more complete and reliable knowledge of Mercury and his telescopic aspect than we already possess. The exact time of the rotation period remains a mystery, and Schiaparelli's view that the planet turns on his axis once only during the period (eighty-eight days) of his revolution round the sun remains yet to be disposed of—if, indeed, the supposition is actually incorrect, as it probably is.

Observations of Mercury may be of great value to settle this and other questions concerning his physical condition. Yet though the prospect is so inviting as regards possible consequences of extreme and lasting importance, we find telescopes are employed upon Mars, Jupiter, and Saturn, which have already been thoroughly studied, and in regard to which there is a poor outlook in respect to any unique or very significant results. In spite of the difficulties attending the telescopic scrutiny of Mercury, this planet, therefore, deserves careful examination, and it is hoped that this will be realized in the immediate future.

I have obtained the most satisfactory views of Mercury at the morning apparitions. Picking up the planet about an hour before sunrise, I have kept the object under observation for two hours or more, and found that at sunrise the definition was remarkably good—in fact, good views can be obtained until an hour after sunrise, the increasing altitude of the object compensating for the fainter aspect of the image.

Schiaparelli preferred observations made in the daytime, and under conditions which many of us would consider detrimental. One of his best drawings was secured when Mercury was only 3 deg. from the sun's limb, the diameter of the planet being then between 4 seconds and 5 seconds. His researches led him to conclude that Mercury had a very dense and imperfectly transparent atmosphere, and that the spots which appeared as very faint, darkish streaks of a reddish-brown color were invariably the same both in position and figure.

Schröter appears to have been the first to discern and depict markings on Mercury, and to give a value for the rotation period. Harding and Bessell supported his deduction that the planet rotated in a period slightly exceeding twenty-four hours, and Mr. McHarg has quite recently corroborated this value. From some observations which I secured in 1906, compared with drawings by Molesworth and others, I was led to favor a period of 24 hours 42 minutes, but could not absolutely rely upon the accuracy of the figures. The investigation is one which obviously demands further attention. I am convinced that the surface spots on Mercury are sufficiently definite to enable their apparent motion to be pretty exactly determined; but the telescope must be large enough to adequately grasp planetary detail, and all the conditions must be favorable. Having compared a large number of telescopes as regards their performance on the planets, I should not care to rely upon any aperture of less than 6 inches, and should prefer one of about 10 inches. I have seldom seen the disk of Mercury sharply defined when less than 20 deg. in altitude.

Two views of Mercury were obtained with the help of a 10-inch reflector, power 310.

Mars is not the only celestial orb on which "canals" are supposed to have been seen, for Professor Lowell ascribes to Mercury a somewhat similar configuration, and his drawings appear in "Monthly Notices" LVII. p. 148. Like the canals on Venus, however, those of Mercury have been discarded in recent years, for they obviously had their origin in an optical illusion which ought to have been discovered at the moment the observations were made.

In 1896 and other years Leo Brenner, with a 7-inch o. g., saw many spots on Mercury, and gave the rotation period as 33.75 days. The late Major Molesworth, at Ceylon, saw many markings on Mercury with a 12½-inch Calver reflector, and for a brief résumé of his and other observations, see "Observatory" for September, October, and November, 1906.

In 1900 Mercury was carefully examined by Prof. Barnard with the great 40-inch refractor of the Yerkes Observatory. He could see nothing whatever of the canal system of markings represented by Professor Lowell, but says that on August 31st, 1900, the planet showed quite distinctly-marked details. There were three or four large dark spots, very much resembling those seen on the moon, with the naked eye.

Many other observers have distinguished the spots. I regarded them as similar to the features on Mars in November, 1882. Mr. McHarg has followed up observations of this planet with great success and diligence; but some doubts may be entertained as to whether his small refractor is a thoroughly capable instrument in observations of planetary detail. Schiaparelli, however, who used an 8½-inch refractor in 1882, and an 18-inch in his later researches, says that the larger instrument had no advantage over the smaller one. The exhaustive character of the eminent Italian's studies of Mercury may be judged from the fact that he made 150 drawings in 1882 and 1883.

Naked-eye observations of Mercury often form the earliest efforts of the astronomical beginner, and success encourages him to attempt more difficult ones. Humboldt, Arago, Smyth, and others aver that Copernicus lamented his inability to catch a glimpse of Mercury, and perhaps the statement has stimulated tyros to perform a feat beyond the powers of the greatest astronomer of the sixteenth century. But the incident related of Copernicus is questionable. In discussing the motions of Mercury he availed himself of observations made at places where clearer skies prevailed than in his own district at Thorn, on the border of the River Vistula, where frequent fogs obscured objects at low altitudes. He does not appear, however, to have definitely complained of failure in picking up the planet. The rapid difference in phase, near the times of his greatest elongations, makes Mercury apparently more brilliant in the spring months *before* the date of maximum elongation, and, in the summer and autumn months, *after* similar dates. Thus in 1910 the planet was brighter at the end of April than after May 2nd (date of E. elongation), and will be brighter early in September than before August 30th (date of W. elongation).

Mercury would be quite a brilliant object were the reflecting power of his atmosphere equal to that of certain other planets. Proctor showed that if Mercury possessed the same reflecting capacity as Jupiter, the former ought to shine when in perihelion and at greatest elongation with twice the apparent brightness of Jupiter under the best aspect.

I have found that Mercury usually becomes visible, when the conditions are favorable, about an hour after sunset, and attains his greatest luster about half an hour before he sets. The planet may be detected about fifteen times in a year in our climate; but this visibility being largely dependent upon atmospheric conditions, he is seen in certain years more often than in others. In May, 1876, I saw Mercury with the naked eye on thirteen evenings, though several opportunities were neglected. In May, 1909, Miss Irene Warner saw the planet on fourteen occasions. He shines with a rosy flashing light, and is frequently quite a bright object in a suitably transparent sky. His star-like scintillations have often caused him to be mistaken for a star, for they are in remarkable contrast to the steady luster of Jupiter and Saturn. Atmospheric undulations act upon the small disk of Mercury almost as effectually as they do upon stellar objects.

Mercury was strikingly displayed in the evening sky at the end of April, setting, as he did, about two hours after the sun. It is to be hoped that both naked-eye and telescopic observations were obtained in abundance, and that our knowledge of this very interesting object will be so much increased as to render the evening apparition of 1910 a really memorable one.—English Mechanic and World of Science.

ELECTRICAL NOTES.

The Hydro-electric Commission of Ontario, who have charge of the construction and operation of the electric power transmission system from Niagara Falls, have decided to use aluminium instead of copper conductors, and have placed an order for 1,500,000 pounds of aluminium wire.

There is no branch of industry to which electricity, by its flexibility and its general convenience in confined spaces, more readily commends itself than to mining work of all kinds. Almost every week, states the Electrical Engineer, there are extensions to electric plants in collieries. At the Canonbie Colliery, Dumfriesshire, the Duke of Buccleuch has just had carried out an important series of improvements, the object of which is to recover the good coal below the level of the pit bottom, which had to be abandoned twenty or thirty years ago owing to the lack of mechanical means of haulage and pumping water. The works now erected include a vertical high-speed engine with a direct-coupled dynamo, running at 550 revolutions per minute. It develops 87 amperes at a pressure of 500 volts. The current is carried down the shaft by double armored special conductors to a distance of 600 yards, and drives a haulage which brings the coal up in rakes to the level of the pit bottom, from whence it is conveyed by horses. An electrically-driven three-throw pump deals with the water.

An article in the Electrical World by Prof. E. B. Rosa gives an account of the work of the International Committee which is to carry on the work of the International Conference on Electric Units and Standards held in London in 1908. The committee arrived at the conclusion that it was impossible to select a more exact value of the Western normal cell in terms of the ohm and ampere than had been done by the London conference, nor would it be possible to agree upon the specifications of the silver voltameter without further experimental investigation, and, in response to an offer from Prof. S. W. Stratton, director of the Bureau of Standards, it was decided that a joint investigation should be carried out there by representatives of that body, with a delegate from the Physikalisch-Technische Reichsanstalt, Berlin, one from the National Physical Laboratory, London, and one from the Laboratoire Central d'Electricité, Paris. These delegates, as appointed by the directors of the several institutions, are Prof. Dr. W. Jaeger, Mr. F. E. Smith, and Prof. F. Laport. The representatives of the Bureau of Standards are Prof. E. B. Rosa and Dr. F. A. Wolff. In addition to the work on standard cells and the silver voltameter, a comparison is to be made of the resistance standards of the several national standardizing institutions. The European delegates have now been in America for some weeks, and it is hoped that the investigations will be completed in about two months.

In the Transactions of the Faraday Society there appears a paper by W. W. Haldane Gee and W. Harrison on an electrical theory of dyeing. The basis of the theory is that any two substances placed in contact are oppositely electrified. In tinctorial processes one substance is a non-conducting solid and the other a liquid, and there is no direct method of determining the potential differences. The methods employed in the deduction of the differences in potential between a liquid and a porous diaphragm are mentioned, and their suitability for the investigation of dyeing phenomena is discussed. The electrical charges of a number of substances, in contact with water, were determined by the U-tube method of Hardy or by the aid of the ultra-microscope, and the results show that, in a colloidal condition or in the form of a fine suspension, substances which are basic in character (basic dyestuffs, aluminium and magnesium hydroxides, etc.) are positively charged, while negative charges are carried by substances of acid character (acid dyestuffs, silica, tannic acid, etc), and such substances as rubber latex, soap, sulphur, paraffin wax, beeswax, starch, etc. The average value of the potential difference with cotton and water is found to be 0.06 volt; with silk and water 0.22 volt, and with wool and water 0.91 volt. The views of Pelet-Jolivet and Wild, and Knecht and Batey, that dyestuffs are electrolytes, and that ionization is increased by dilution and rise of temperature, are supported. Wool and silk becoming negatively charged in contact with water, it is natural that basic dyestuffs (which carry a positive charge) should be capable of dyeing them from neutral solutions, but that when, by the addition of acid, the electrical condition of the fiber is changed (becoming positive), the affinity for these dyestuffs is diminished and that the power of fixing the predominant negative ions of acid dyestuffs is increased. In the general conclusions, it is stated that although the electrical theory explains why one type of coloring matter is selected by the fiber in preference to another, the method of fixation is still a matter of doubt. A table is given, showing the laws of contact electricity, colloidal coagulation, dyeing, and capillary ascension in absorbent materials and some effects of temperature.

ENGINEERING NOTES.

A large number of tests on the mechanical properties of soldered copper joints have been made with a view to determining the effect of the various processes involved on the strength of the joint and of the copper itself. The effect of rolling the sheet into tubes is to increase the limit of elasticity and decrease the elongation, but this effect is practically removed by the heating during soldering. By drawing the tube after the joint has been made the mechanical properties are improved, this effect being particularly noticeable in tubes made from thin sheets. Annealing completely removes the increase in elastic limits. Thick-walled tubes show a greater tendency to break at the joint than thin tubes. Tests made at elevated temperatures show that there is very little effect on the elastic limit of the anpealed unsoldered materials up to 400 deg. C. The elastic limit of the unannealed specimens and the tenacity of all the samples decrease with increase of temperature. A decrease of elongation is specially noticeable between 200 deg. and 300 deg. C. Drawing the tube subsequent to the soldering appears to favorably influence the strength of the joint, and the effect of cold-working appears to persist at higher temperatures.

A very successful method of ventilating freight and passenger cars has been devised by Mr. T. H. Garland, supervisor of refrigerator traffic on the Chicago, Burlington and Quincy Railroad. The principle of the ejector has been made use of to promote the circulation of air in cars. On the passenger car the ventilator is placed on the roof and opens into the deck light or clerestory window. Air entering the intake pipes, when the train is in motion, is deflected through a right angle and is blown out of the ventilator again, drawing with it air that is in the car. It is said that the amount of air taken out by each ventilator is 400 cubic feet a minute. When applied to a sleeping car, a duct is run down to some convenient place in the neighborhood of each lower berth, and in this way there is a constant but mild movement of air from the lower levels in the car.

Bulletin No. 36 of the University of Illinois consists of a paper on "The Thermal Conductivity of Fire-clay at High Temperatures," by Messrs. J. K. Clement and W. L. Egy. The fire-clay specimens are cylinders 40 centimeters long, 12 centimeters in diameter, with a hole through the center 3.5 centimeters in diameter for the reception of a heating coil of nickel wire wound on a porcelain tube. The cylinders are further provided with two long holes 3 millimeters in diameter parallel to the axis and extending to the central plane. Through these pass the platinum platinum-rhodium thermocouples, by means of which the temperatures at two points of the central plane are determined. The specimens are inclosed in a fire-clay furnace, which has an internal diameter slightly greater than the external diameter of the specimens. The heating current is measured by means of a Weston voltmeter and shunt, and the thermocouples standardized by means of zinc, silver, or copper melted in a carbon crucible in a special furnace. The electromotive force of the couple is measured by potentiometer and galvanometer. Two samples gave constant heat conductivities of 0.0026 and 0.0036 respectively between 300 deg. C. and 800 deg. C., one other increased from 0.0021 at 300 deg. C. to 0.0023 at 700 deg. C., while a fourth increased from 0.0024 at 400 deg. C. to 0.0026 at 800 deg. C.

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TRADE NOTES AND FORMULÆ.

Metals, especially silver, can be colored black by rubbing with a cloth moistened with linseed oil varnish and dipped into finely washed graphite. Red ferric oxide (bloodstone) can be added to vary the shade. Aging, or antique finish of silver, is done by rubbing it with a mixture of 6 parts of graphite, 1 of bloodstone or red ocher, with a cloth dipped in turpentine oil.

Ultramarine Green (J. Rhein.)—Coat the object with a copal lacquer containing little oil, and brush over the whole surface or any special part of it which is to be bronzed with ultramarine green-bronze, using a hair brush, but not moistening it in turpentine oil. Let the object dry slowly in a place free from dust, and if the bronzing is good, it may then be glazed. A good effect is produced by penciling the raised parts with gold or silver bronze, or gilding special parts with leaf gold.

A Beutiful Copper Bronze (J. Rhein.)—With each gill (⅛ quart) of siccative mix about 20 drops of raw linseed oil, coat the object with this mixture and bronze with copper bronze, to which has been added a little red cinnabar (vermilion). Do not moisten the brush, which should be a hair pencil, in turpentine oil, but use it dry. The bronze powder and the cinnabar must, of course, be very thoroughly mixed. Take up but very little bronze on the brush at a time. Repeat the bronzing several times, until the desired luster has been obtained, then let the object dry slowly and glaze with reddish brown spirit lacquer.

A Very Fine Brown for Smooth or Partially Smooth Surface. — Give the object a thin, even coating of copal lacquer with an otter's hair brush; if there are raised decorations, bronze these heavily with pure copper bronze, and the hollows, whether smooth or ornamental, with copper bronze to which a considerable amount of graphite has been added. Put on the latter with a dry brush. Dry the object, then coat over carefully with copal lacquer, and bronze the whole surface lightly with copper bronze, and dry well. Coat over the bronzing with wax dissolved in turpentine oil, and polish with wash-leather. If the color is too light, brush with graphite before applying the wax.

Hardening of Plaster.—To impart greater hardness to plaster borax should be added to it. Plaster to which borax has been added, it is true, sets slowly, but after a time becomes exceedingly hard. If freshly burned, finely pulverized plaster is mixed with alum solution (12 parts gypsum to 1 part alum) poured out and allowed to harden, after drying, ground and burned in shallow pans at a dark red heat; the pieces thus treated present a milky appearance and can be easily pulverized. If the plaster thus pulverized is mixed with alum solution, in the proportion of 1 to 3, the mass will harden slowly and assume the appearance of alabaster. The mass remains fluid longer than ordinary plaster, but does not work and generates no air bubbles; after at most an hour, the mixture hardens. From ordinary burned gypsum also a plaster mass that quickly becomes very hard, may be prepared. For this purpose we dissolve in 100 parts of the water required for the plaster, 16 parts of sal-ammoniac and 16 parts of alum. The mass after mixing does not harden any more quickly than the burned alum gypsum, but becomes just as hard as this. In mixing the plaster, only enough water should be used to form a thin paste; care must also be taken that the mixing water and the plaster are of about equal temperature. Good fresh plaster should not lie heavy at the bottom on mixing. It should combine evenly and slowly with the water, forming no humps, and in setting it should become evidently warm, which is proof that a sufficient quantity of water has entered into chemical combination with it. Rapid introduction of the plaster into the water and careful mixing are also prescribed. In regard to the mixing of alabaster gypsum it must also be noted that it requires to be mixed thicker than ordinary gypsum and should not be poured immediately after mixing.

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